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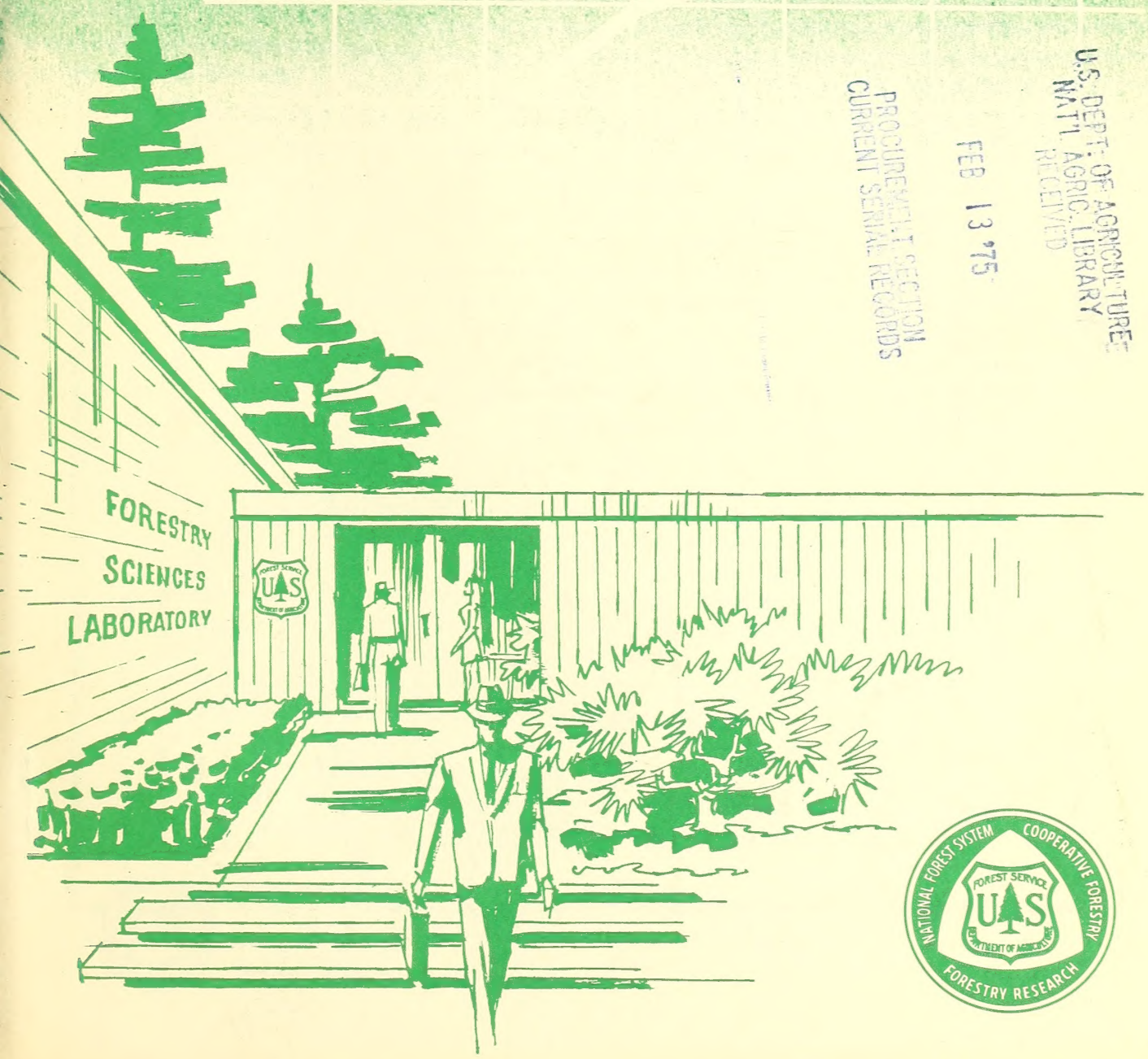

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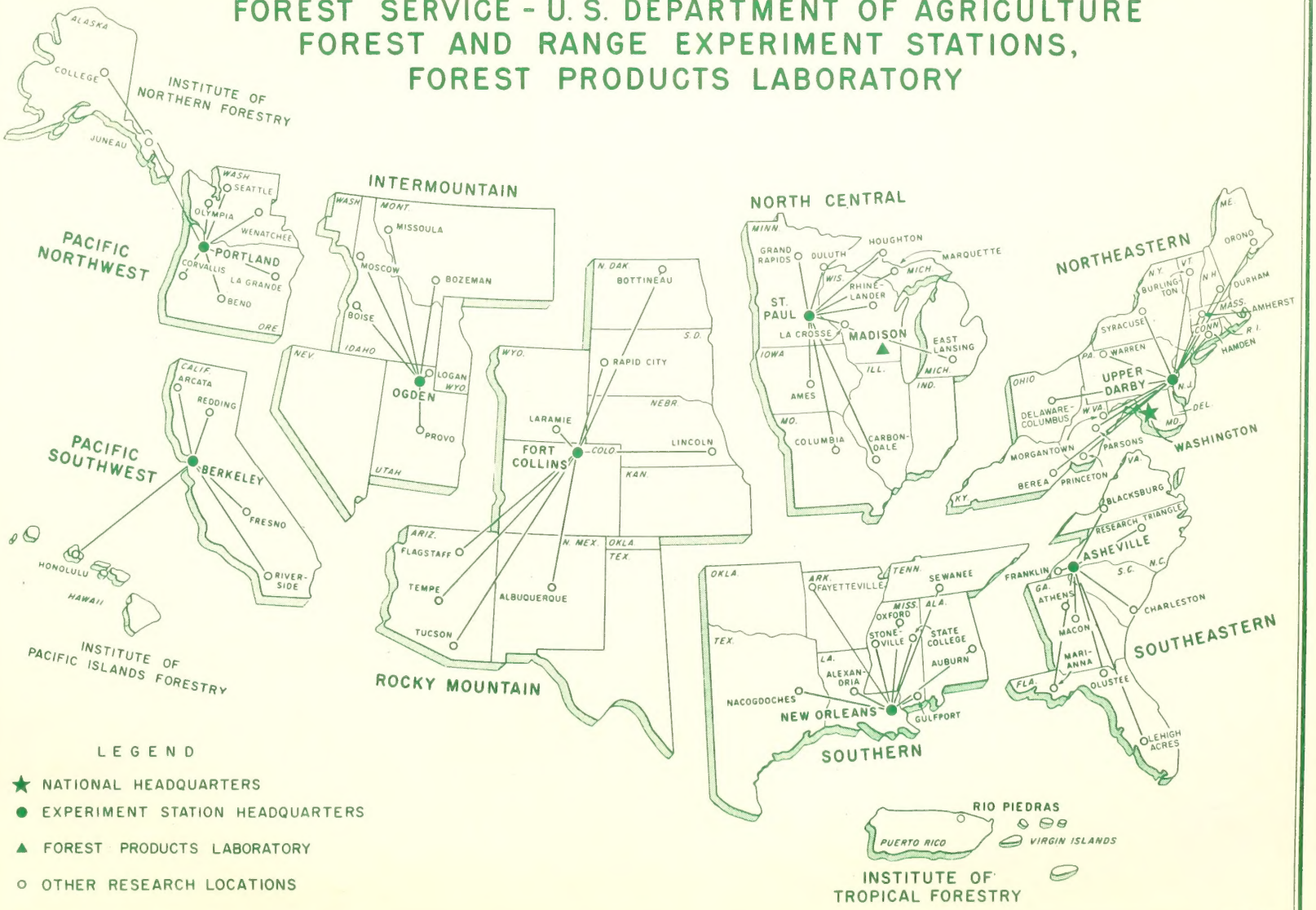

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- ○ OTHER RESEARCH LOCATIONS

Revised 10-1-70

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
WASHINGTON, D.C. 20250

IN REPLY REFER TO

1380 (4000)

Dr. T. K. Cowden
Assistant Secretary
U. S. Department of Agriculture
Washington, D. C. 20250

Dear Dr. Cowden:

This report of research accomplishments by the Forest Service and its cooperators represents another scientific forward step in forestry research. The report provides you and other administrators in the Department of Agriculture with a brief statement of the significant achievements of our scientists during the past year. Within the Forest Service, it provides a summary of new information that is available to improve planning and policy formulation as well as to raise the level of management of the forest lands of the nation. It also brings us up-to-date on our progress in pushing back the frontiers of knowledge. We send this report to other agencies and to our cooperators for their use in coordinating research and putting research findings into action.

This report has broken from past tradition of organization along functional lines. This time, we have tried to show how our accomplishments relate to improvement of the environment, to the interaction between environmental and production activities, and to greater output of multiple products from forest and range lands. In this era of concern for the environment, we are proud to show that about two-thirds of our program and some of our most significant accomplishments relate to environmental problems. We feel we have made progress in this area. Our research related to production gives us alternative ways to reduce the costs of management, to extend supplies that are now available, and in some cases to create new supplies that have not existed before.

Sincerely,

Edward P. Cliff

EDWARD P. CLIFF
Chief

FOREWORD

Forest Service research plans are coordinated through the U.S. Department of Agriculture's Office of Science and Education with research in other USDA agencies, with that conducted under the Hatch Act at land grant institutions, and with forestry research under the McIntire-Stennis Act at schools of forestry. Coordination of research with other educational institutions, private enterprises, nonprofit institutions, and other public agencies is maintained mostly through direct contact between people of these organizations and those of the Forest and Range Experiment Stations. Federal, State, industry, and university cooperation in solving mutual problems is achieved through cooperative agreements that provide for joint development and support of the research by the cooperators.

This report is arranged by research subject areas in order that the reader can go directly to the areas of interest to him. Each accomplishment is summarized in a single, short paragraph followed by an abbreviation denoting the Forest Service research unit best able to supply additional, detailed information and copies of the 1,100 publications listed. Underscored numbers in parentheses following unit abbreviations refer to publications listed at the end of each section. The research units and the abbreviations used in keying the accomplishments follow. Their locations are shown on the map in the inside front cover. For further information, publications, or service, any of these units may be contacted:

PNW - Director,
Pacific Northwest Forest and Range Experiment Station
809 NE 6th Avenue, P. O. Box 3141
Portland, Oregon 97208

PSW - Director,
Pacific Southwest Forest and Range Experiment Station
1960 Addison Street, P. O. Box 245
Berkeley, California 94701

INT - Director,
Intermountain Forest and Range Experiment Station
507 25th Street
Ogden, Utah 84401

RM - Director,
Rocky Mountain Forest and Range Experiment Station
240 West Prospect Street
Fort Collins, Colorado 80521

NC - Director,
North Central Forest Experiment Station
Folwell Avenue
St. Paul, Minnesota 55101

NE - Director,
Northeastern Forest Experiment Station
6816 Market Street
Upper Darby, Pennsylvania 19082

SE - Director,
Southeastern Forest Experiment Station
Post Office Building, P. O. Box 2570
Asheville, North Carolina 28802

SO - Director,
Southern Forest Experiment Station
T - 10210 Federal Building, 701 Loyola Avenue
New Orleans, Louisiana 70113

FPL - Director,
Forest Products Laboratory
North Walnut Street, P. O. Box 5130
Madison, Wisconsin 53705

ITF - Director,
Institute of Tropical Forestry, University of Puerto Rico
Agricultural Experiment Station Grounds, P. O. Box AQ
Rio Piedras, Puerto Rico 00928

WO - Deputy Chief for Research
Forest Service, U.S. Department of Agriculture
Washington, D.C. 20250

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I. IMPROVING THE ENVIRONMENT

A. Reducing Pollution

1. CONTROLLING SOIL EROSION

At Wenatchee, Washington, tracing movement and dispersion of soil-sized fluorescent willemite ore particles was found to be a promising method for detecting and describing soil erosion. Actively eroding and stable sites are readily identified; size of particles in motion and causal agents may also be inferred. The equipment is simple to operate, and no health hazards are involved.--PNW (11).

Quick establishment of elk sedge on disturbed or depleted grazing lands of Oregon and Washington would be desirable for erosion control. Elk sedge (Carex geyeri) is a grasslike plant native to eastern Oregon and Washington and possessing extensive fibrous root systems and apparent high drought tolerance. Efforts to reproduce the plant from seeds in the laboratory have not been successful; "cores" or plugs, however, have been transplanted successfully to the laboratory to investigate this method of reproduction. Elk sedge also showed positive response to nitrogen and potassium fertilization.--PNW (12).

Simulated rainfall studies of infiltration and erosion on a granitic subalpine ridge in north-central Idaho showed that infiltration rates are largely determined by a combination of three soil factors--organic-matter content, clay content, and moisture-holding capacity. The rates, however, are not highly correlated with any single factor.--INT (14).

Eight grass species were planted to improve abandoned cropland and rangeland areas in the sagebrush type in west-central New Mexico. Studies of these eight indicate Russian wildrye and buffalograss are best suited for erosion control and soil protection; they were the only species that maintained good stands at the end of four growing seasons.--RM (13).

2. UTILIZING SOLID WASTES

Millions of tons of tree bark are produced annually by the wood products industries of the Pacific Northwest. Most of this material is currently disposed of by burning, which creates a major source of air pollution. Physical and chemical properties of the bark of major tree species of the Pacific Northwest make this material well suited for various uses--mulching, soil conditioning, drainage improvement, animal bedding, protecting logging sites from erosion, protection and stabilization of road and highway cut and fill slopes, filter bed material for effluent disposal, and soil fertilizer (when fortified with poultry manure or nitrogen).--PNW (18).

3. CHEMICALS IN THE FOREST ENVIRONMENT

Degradation rates of four common brush control chemicals--2,4-D, 2,4,5-T, amitrole, and picloram--were measured in forest floor material from a red alder stand in the Pacific Northwest. The study, conducted in the laboratory under favorable conditions for herbicide degradation, suggests the four herbicides have little significant impact on the quality of the forest environment when properly used. All four herbicides were degraded but at markedly different rates. Amitrole and 2,4-D were most rapidly degraded.-- PNW (26).

4. AIR POLLUTION EFFECTS AND CONTROL

Although some laboratory tests have indicated that certain fire retardants may decrease the threat of air pollution from slash burning, tests in Oregon in 1969 showed apparently contradictory results. Large-scale field tests in ponderosa pine slash showed that diammonium phosphate, when sprayed on slash to be burned, causes less total fuel reduction, greater particulate production, and higher levels of some undesirable chemical compounds than slash that was untreated.-- PNW.

Preliminary results of air quality research, from a cooperative program with Forest Service Region 1 and Washington State University, are favorable. Convection columns rose to a higher altitude, and smoke plumes were more greatly dispersed from Miller Creek burns when fuels were relatively dry and lapse rates were favorable than under the reverse conditions. Prediction of convection column height before prescribed fires are ignited now appears feasible.-- INT (34).

A 3-month experiment near San Bernardino during June, July, and August 1969 demonstrated that both the fire behavior and air pollution aspects of the marine air invasion can be studied concurrently. The relationship between the diurnal and day-to-day variations of total oxidant concentrations and meso-meteorological factors is being determined. This information will be used to develop a synoptic climatology of total oxidant air pollution concentrations and thus the smog damage potential to specific forest areas. This is a joint study of Fire Meteorology and Biology and Control of Forest Disease Research projects of the Station.--PSW.

(For additional items relating to IA see paragraphs under IIB 10; to IA 1, see under IIE and IIG 3.)

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B. Improving Wildlife Habitat

1. INTEGRATING WILDLIFE AND OTHER LAND USES

Much-needed hunting grounds and income for rural landowners in the South can be provided by combining small forest holdings and leasing the hunting rights. Hunters are able and willing to pay for hunting privileges on private land. Gross income to landowners for hunting leases usually ranges between $0.50 and $1.00 per acre.--SO (5).

Narrow clearcut areas in the Appalachian forests had more birds during the breeding and late summer periods than did uncut stands, but fewer birds during winter. Analysis of bird habitats indicated that about three-fourths of the variation in bird populations was accounted for by a single variable--density of the understory.--SE (3).

Clearcuttings in the southern Appalachians can be too small or too large for deer habitat. A 21-acre clearcut is a desirable compromise. Because they remain accessible to deer, heavy selective cuttings appear to have an important advantage over clearcutting.--SE (2).

Ruffed grouse in Michigan can be managed most fruitfully in the transition between lowland and upland soils. This zone is characterized by aspen, whose canopy allows sufficient light for growth of herbs and shrubs and whose buds provide a key food. Clearcutting in 10-year cycles with a 40-year rotation will maintain the aspen type as productive grouse habitat.--NC (1).

Deer habitat on southwestern forest lands can be improved by maintaining forest openings and borders, thinning trees on overstocked sites, minimizing the amount of slash cleanup, including forbs and browse in range reseeding practices, and allocating forage between deer and cattle.--RM (4).

2. EVALUATING WILDLIFE HABITAT

Current twigs of American beautyberry and rusty blackhaw, two southern browse species, are nutritionally adequate for deer only during the period of rapid growth in the spring. Leaves are the most nutritious parts of the plant tissues studied, although ripe fruit may be of value in early autumn.--SO (33).

The rumen of mule deer in Utah contained 13 identifiable types of bacteria and one genus of ciliate protozoa. No difference in bacteria could be detected when deer were fed natural browse plants or alfalfa hay. Highest protozoal populations were from animals fed rations containing barley. There were indications that salt in the ration favored ciliate protozoa.--RM (28).

Browse grown in the open is usually superior nutritionally to that grown under southern pines. However, important exceptions occur; e.g., Japanese honeysuckle, Alabama supplejack, and rusty blackhaw. Consequently, these species may have special values for timbered sites.--SO (18).

Game managers can evaluate greater prairie chicken habitat with the aid of a new tool developed in Colorado. Numerical values are systematically assigned to individual habitat components. In aggregate, these individual ratings indicate the potential value of a specific habitat for greater prairie chickens. Separately, they indicate habitat components that need improving.--RM (12).

Mistletoes serve as high energy concentrates of particular value to deer during the winter months in the Southwest. These plants are highly digestible and contain good yearlong levels of some nutrients. Crude protein is marginal and calcium:phosphorus ratios are undesirably high in some species.--RM (39).

Three years after a wildfire in spruce-fir forest in New Mexico, aspen sprouts were 146 times as abundant on a burned area as on an unburned area. Five years after the wildfire, deer and elk could not utilize forage on the 8- to 10-foot high aspen sprouts.--RM (27).

Grasses and forbs are the major components of the mule deer's winter diet in the big sagebrush type in Colorado. Shrubs dominate the winter diet of deer only to the extent that forbs and grasses are made unavailable by snow. This condition is probably the critical forage period, but terminal starvation occurs later even though forage abundance and quality are improving.--RM (13).

Prostrate summercypress, a shrub from the Soviet Union, may fill the need for a succulent forage plant on Utah's calcareous soils. Nine other species of Asiatic origin are useful for keeping thicket-forming shrubs open and stunted so the new growth is available to grazing animals.--INT (30).

Gardner saltbush and Nuttall saltbush reproduce vegetatively as well as by seed. However, principal means of vegetative reproduction differ between these two closely related species. Gardner saltbush reproduces mostly by root-sprouting, whereas Nuttall saltbush spreads mostly by layering. Both species appear to be fire-resistant plants with desirable browse characteristics.--INT (26).

In uniform habitat, the distribution of deer and elk pellet groups followed the Poisson series. In heterogeneous habitats, the negative binomial model closely approximated the distribution of pellet groups.--PNW (23).

(For additional items relating to IB see paragraphs under ID 1, 2, 4, and 5; to IB 1, see under IIIA 4.)

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C. Opportunities for Outdoor Recreation

Skiers in the Great Lakes region are a young group. More than half are less than 23 years old. They come from families with above-average incomes. They are predominately students or beginning business-professionals. They ski only one-half as many days per year as do western skiers, and only one-third as much as eastern skiers. Four-fifths of their ski trips are either single-day or weekend trips. These patterns work against the financial success of areas remote from cities.--NC.

The Boundary Waters Canoe Area has a long history of major forest fires and spruce budworm outbreaks. The natural ecosystem is subclimax and fire is necessary for its maintenance. The distribution of plant communities can be understood only when related to past natural disturbances, and the climax concept has little relevance to the BWCA's actual forest history.

Twelve natural plant communities have been delimited. Their composition and structure are sufficiently unique to warrant separate management consideration. Eighty to 90 percent of the virgin forest stands date from forest fires in the past 400 years.--NC (6,22,23).

A net count procedure or a self-registration procedure can estimate visitor use at developed recreation sites accurately and inexpensively. Electric highway traffic axle counters count vehicles coming and going, then print the net number of vehicles present. These nets can be related to sample counts of visitors and provide visitor use estimates of good precision. A self-registration procedure similarly related to sample counts was precise and even less expensive.--INT (31,34).

A study of 34 campgrounds in northern Minnesota showed that some facilities were used over five times as much as others. Occupancy was significantly related to (1) proportion of waterfront campsites, (2) age of campground, and (3) fishing reputation of nearby lakes.--NC (17).

Are campers changing? Is management in tune with the goals of many campers? Although an increasing minority prefer primitive environment oriented camping experiences, a much larger and increasing number prefer highly developed campgrounds. For the latter, camping is more of a social than environmental experience, and the expectations of a sizable portion of campers have changed more rapidly than have campgounds or the perspective of managers. When an intensively developed campground is planned, the social character of its use -- such as accessibility, easy contact with other campers -- must be considered in its design.--PNW (9).

For every new campground built by Federal, State, or county agencies since 1961, ten campgrounds have been built by the private sector for commercial operation. Camping today has a broad based appeal. Very few users regard it as an inexpensive substitute for a motel. Most of today's campers are seeking fun, recreation, convenience, and variety. They are willing to pay more because they expect more.--NE (15,16).

Comprehensive regional environmental planning -- a dream or a fact? Instead of following the usual multidisciplinary, often uncoordinated approach, a single interdisciplinary base plan to guide regional environmental quality planning was developed for Nicasio -- a 36-square-mile undeveloped mountain forest valley in California. The valley will soon be part of San Francisco's suburbia. The plan will be the basis for considering and coordinating all major land use needs and their impacts.--PSW (30).

Small game hunting in the Appalachians is closely related to access. Where roads and trails are well distributed, hunting pressure and game harvest are well dispersed. Even though many hunters did not hunt from roads and trails, they use this access to gain entry.--SE (11, 12).

A northwestern study indicates that competition between appreciative wildlife use (bird watching, game watching) and consumptive use (hunting) will greatly increase in the years ahead. Participation in appreciative

uses, predominately by highly educated urbanites, is growing rapidly. Hunting and, to a lesser degree, fishing are declining; these are largely participated in by ruralites less well educated.--PNW (7, 8).

What subject matter, stimuli, and communication approaches in interpretive programs are most effective for holding visitor attention and transmitting information regarding use and understanding of outdoor environments? In a Pacific Northwest study, (1) animals were of greater interest to park visitors than plants, (2) audio messages were remembered better than printed labels, (3) facts were remembered better than concepts, (4) specimens and models were remembered better than still pictures, and (5) children liked something they could manipulate.--PNW.

A double sampling system based on traffic flow records will provide reliable estimates of mass and dispersed types of recreation use for large areas at low cost. Related procedures work equally well for estimating use at visitor information centers, reservoirs, and wilderness-type areas.--SE.

Vacation homes are growing rapidly. In Michigan, 89% are located within a 5-minute walk of a body of water. Households with incomes over $10,000 a year, professional people, and people over 55 years of age tend to locate their vacation homes along the Great Lakes. Lower income families and those from small cities or rural areas generally choose sites on streams or in areas not associated with water. Two-thirds of all the vacation homes are within 200 miles of the owner's primary residence, but only 9 percent are less than 25 miles. In the next few years, Great Lakes sites will probably become increasingly more popular than sites along streams or inland lakes.--SE (28).

Exotic ornamentals useful for scenic enhancement in Florida are often susceptible to frost and vegetative competition during their early months. Fertilization can overcome these difficulties by optimizing early growth. Responses were measurable in a month. At 6 months, fertilized trees were 50 percent taller and 83 percent thicker. At 4 years, they were 31 percent taller, 60 percent thicker, had 24 percent wider canopies, and 156 percent more basal area than unfertilized trees.--SE.

(For additional items relating to I C see paragraphs under I B and III E.)

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D. Developing Range Resources

1. EVALUATING RANGE RESOURCES

Color infrared space photographs of the earth, similar to those obtained by the Apollo 9 mission, provide the instantaneous synoptic base for classifying and prestratifying groups of closely related plant communities.

However, as more detailed quantitative information is required, support aerial photographs at various scales are needed to provide sampling bases.--RM (2).

Electronic capacitance instruments have promise of providing rapid, accurate, and nondestructive methods for measuring the standing crop of shrubs. Correlation between standing crop and meter reading was 0.8 for whitesage in Utah, 0.9 for fourwing saltbush in California, and 0.8 for big sagebrush in Wyoming.--RM (3).

2. CHARACTERISTICS AND FORAGE VALUES OF RANGE PLANTS

Burroweed competes only moderately with perennial grasses on southwestern ranges. Its root system and major growth periods are different from the grasses. A good forage plant, that fits the ecological niche now occupied by burroweed, is needed to provide forage in early spring.--RM (4).

American jointvetch, a native annual legume, shows promise for improving wildlife and livestock forage on southern Florida ranges. On a 10-acre wet prairie site, it was successfully established by disking and light fertilization. Over a 4-year period it reestablished annually, producing 1/2 to 2 tons of herbage per acre per year. With associated herbs, total production reached 2 to 3 tons per acre.--SE (7).

Mesquite seedlings may continue to emerge from the soil for many years after the mesquite has been cleared from Arizona ranges. One velvet mesquite seed, out of 450 seed planted in 1948, remained viable in the soil for 20 years. Most of the other seeds had germinated previously.--RM (6).

In the pine types of Arizona, Kentucky bluegrass, Arizona fescue, and mountain muhly are preferred by cattle in the summer. Prairie junegrass is most preferred in spring and fall in the pinyon-juniper type.--RM (5).

At the time of maximum standing crop, alpine plants in Wyoming form a spectrum of digestibility ranging from 35 to 78 percent. The primary forage species for sheep occupy intermediate positions in the spectrum. Carex elynoides, red fescue, and American bistort are the most digestible of the primary forage species.--RM (9).

Idaho fescue is the primary herbage producer in grasslands and elk sedge in the aspen type on Black Mesa, Colorado. Forage value of Idaho fescue is more than twice that of any other species. Grasses are low (perhaps deficient) in crude protein and phosphorus after seed have ripened. Forbs, though not readily grazed, help maintain a satisfactory nutrient level in the diet of cattle.--RM (8).

3. LIVESTOCK GRAZING PRACTICES

Perennial grasses are the most reliable source of forage on semidesert ranges in southern Arizona. Highest yields of perennial grasses are obtained by controlling competitive shrubs such as mesquite, grazing about 40 percent of the current year's herbage production, and resting the range in alternate summers.--RM (17).

Simulative grazing (clipping) reduced the production of big sagebrush most when applied in July, moderately when applied during spring, and least when applied during late summer through winter. Three-tip sagebrush responded similarly during July, but it was most tolerant during April and May. Three-tip sagebrush was less tolerant than big sagebrush during the fall and winter months.--INT (22).

Feeding protein supplements to cattle on southern ranges as salt-cottonseed meal was less expensive than daily or alternate-day feeding of cottonseed cake. Low production, however cancelled the saving. Alternate-day distribution costs only about 60 percent as much as daily feeding. This method further improved cost-return relationships by increasing calf production 8 percent and weight of cull cows 70 pounds each.--SO (15).

Seasonal opening and closing of watering places on the Santa Rita Experimental Range in Arizona reduced utilization near water only if utilization for the entire pasture was moderate to light, and if the closed period included the summer growing season. Rotating use of watering places should work best in large range units with waters far apart.--RM (18).

Native forage growing under young stands of pine may be successfully grazed by cattle if precautions are taken to prevent trampling and browsing of the trees. Minimal damage to pine seedlings and satisfactory calf production are obtained by providing adequate amounts of native range supplemented with improved pasture during the summer, and wintering cattle off the range.--SE (16).

Continued moderate grazing after sagebrush control did not retard the revegetation process or accellerate the reinvasion of sagebrush on subalpine ranges in Wyoming. Desirable forage grasses quickly increased in vigor and revegetated the area after sagebrush was killed. Deferment of grazing for 1 to 3 years did not amplify the results of sagebrush control.--RM (21).

The use of warm-season, native grass ranges in the summer and cool-season, tame grasses in spring, fall, and winter provides year-long grazing in the Ozarks. This deferred rotation management system maintains maximum forage production.--NC (10).

Grazing crested wheatgrass to a 1-inch stubble during spring, fall, and both spring and fall had little effect on vegetative characteristics of seeded stands in Colorado. Spring-and-fall use resulted in the most forage production, the largest grazing season, and the highest beef production, 177 pounds per season. Spring grazing was next, and fall grazing produced the least animal gain.--RM (11).

Condition and trend of crested wheatgrass stands in Nevada are influenced more by season of use than by grazing intensity. Climate, site, initial density of grass, insects, and rodents influence the response of stands to season and intensity of grazing.--PSW (19).

Seeded ranges in conjunction with native ranges can effectively increase productivity and income from ponderosa pine ranges in Colorado. Average weight of weaned calves was 33 pounds higher, and gross income per calf $8.95 larger from combined use of seeded and native range then from native range alone. Seeding requires an initial investment of about $8.50 per acre which can be repaid within 3 years as a result of increased grazing capacity.--RM (13).

On ponderosa pine ranges in Oregon, deferred rotation grazing at a light stocking rate results in improved herbage production. With heavier stocking rates the advantages of deferred rotation over season-long grazing are negligible. Elk use decreases as the stocking rate for cattle increases. Deer are less sensitive to grazing pressure than cattle.--PNW (20).

Sherman big bluegrass should be utilized to a 4-inch stubble under season-long grazing. Under this rate of grazing, beef production averaged 78 pounds per acre, higher than the production from any other seeded or native species tested at the Manitou Experimental Forest, Colorado.--RM (12).

On seeded ranges in Colorado's ponderosa pine zone, a mixture of crested wheatgrass, smooth brome, and yellow blossom sweetclover provides the best sustained forage yields and livestock production. Grazing can begin when spring growth averages 4 inches. Forage should be grazed to an average 2-inch stubble height during the grazing season.--RM (14).

4. RANGE PESTS

In Utah, uncontrolled populations of pocket gophers were very destructive to mountain grasslands that had been seeded. With protection from gophers, good stands of grasses and forbs were obtained. No ideal control for pocket gophers has developed.--INT (23).

Within one year, pocket gopher control in western Colorado resulted in an increase of available herbage of nearly 200 pounds per acre. Forbs accounted for most of the increase. Grass production was not much affected by gopher control.--RM (24).

5. RANGE ECOLOGY

Two diverse, intergrading plant communities are present in the alpine zone of the Medicine Bow Mountains, Wyoming. Discrimination on the basis of soil characteristics and elevation is only partially successful. Because of the wide intracommunity variation in these characters, the discriminant function has a 26 percent probability of misclassification.--RM (28).

Where the density of pinyon and juniper is low, herbage production is similar on the Springerville, Gem, and Tortugas soil series in Arizona. Where the tree cover is appreciable, however, Springerville soils produce

much less perennial herbaceous vegetation than the other soils. The difference among soils does not appear to be due to soil moisture, nitrogen, or phosphorus.--RM (26).

Two grassland communities, Agropyron-Melica and Festuca-Agropyron - Antennaria, exist on relatively undisturbed areas in the mountains of Idaho. Vegetation and certain soil characteristics vary between communities. Herbage production is related primarily to exposure and water-holding capacity of the soil rather than to community.--INT (27).

6. RANGE IMPROVEMENTS

In the Ozark Mountains, grass production on certain sites can be increased 40 to 100 times by aerially spraying 2,4,5-T, followed by burning, fertilization, and seeding native grasses or tall fescue.--NC (29).

Pot tests under greenhouse conditions indicate that production may be increased by fertilization of mountain grassland soils in Colorado. These results must now be verified under field conditions.--RM (31).

The use of earthen pellets containing grass seed resulted in some seedling development on southwestern ranges, but better stands resulted from methods commonly used. Furthermore, costs of pellet seeding were higher, ranging from $7 to $14 an acre as compared with $3 to $7 an acre for other methods.--RM (30).

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E. Trees to Enhance the Environment

During the past 30 years the average community sound level has risen an estimated 1 decibel per year -- that is an eightfold increase in total loudness. Preliminary results of research in cooperation with the University of Nebraska indicate that tree barriers can make a 50-percent reduction in apparent loudness. Living screens of trees and shrubs have a great potential to improve the environment esthetically for both sight and sound.--RM (1).

In the course of breeding southern pines for improved yield of naval stores at Olustee, Florida, mutant trees with potential ornamental value, such as short needles or dwarfs, have been found. Such mutants are preserved by vegetative propagation, and most are available to organizations concerned in research with ornamentals. - SE (2).

Collectors of medicinal plants need additional information on the potentially important species in the Appalachian Region. A new handbook describes 126 medicinal plants of the region. Information on plant collection and preparation as well as reputed and recognized usages is included.--NE (3).

(For additional items relating to I E see paragraphs under II G 2.)

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II. IMPROVING THE ENVIRONMENT AND PRODUCTIVITY

A. Reducing Fire Losses

1. FIRE PREVENTION AND HAZARD REDUCTION

Fire risk potential among rural populations residing in areas with high incendiary fire occurrence rates can be identified. A new publication provides information on attitudinal characteristics related to individual fire risk reputation (high vs. low) in a selected Southern rural community. Although the relations found are tentative, they can provide a basis for some valuable suggestions toward tailoring fire prevention actions to reach high-risk individuals. - SO (1).

Local rural opinion leaders can serve as communicators for fire prevention programs. A communicator may be an initiator, a legitimist, or a diffusor. A Louisiana study provides valuable suggestions as to ways and means of identifying local opinion leaders and getting their aid in functioning as communicators. Such information is valuable to prevention planners. - SO (8).

A survey of fire-cause accounting in two selected Mississippi counties indicated a high degree of uncertainty in almost half of 243 fires investigated over a 2-year period. This raises serious questions regarding the reliability of cause data from fire reporting systems with implied absoluteness. It suggests that accuracy, hence usefulness of fire-cause data for prevention and presuppression planning purposes, would be increased through the adoption of an unknown category and/or the use of qualifiers to indicate degree of certainty of causes. - SO (1).

Kindergarten and first grade children participating in a 20-lesson television program on fire prevention and conservation education showed significantly higher test scores than did those from unexposed control classes. These results were obtained in an experiment conducted within the broadcast range of the educational TV channel in Redding, California. These results mean that fire prevention and other conservation education materials can be presented to children at an age when they are most likely to start fires. - PSW.

An analysis of detailed fire-cause information from 10 counties in Massachusetts revealed that fires resulting from debris burning are an even greater problem than originally suspected. Debris burning by local residents accounted for almost 40 percent of all positively determined causes. Housewives and skilled or professional men were equally and most generally responsible. The analysis suggests a change in emphasis for certain fire prevention activities. - NC.

Feasibility of safely reducing southern California chaparral fuel hazard with prescribed fire was demonstrated in May 1969, when the first of several small (4- to 6-acre) plots were burned after preparation with partial bulldozer smashing and aerially applied desiccants. Seventy percent of green fuels were consumed and about 75 percent of the 35 tons per acre fuel volume was burned. - PSW.

The "Chevron" burn (so named because the diagonal lines of fire meet to form an angle at the high point being burned) has recently been devised as a prescribed burning technique on hilly terrain. Perfection of this new method will provide another alternative in regulating intensities of fires in Piedmont and mountain areas. - SE (14).

Standard seasonal foliar moisture (FM) curve, used to conduct prescribe fires in chaparral elsewhere, cannot be used for Arizona chaparral. Day-to-day FM variations during dormancy make seasonal curves unreliable. Mathematical and graphical methods, based on 3 years' data, show promise for a synchronized FM estimating system. Preliminary trend curves for manzanita and oak may help land managers conduct prescribed burn more efficiently. - RM (9).

Creeping sage, a low fuel volume plant being tested for fuel breaks, can be grown by seed and cuttings. Dormancy of creeping sage (Salvia sonomensis) seed has been broken by soaking in gibberellic acid. Germination of up to 60 percent occurred in seed soaked for 1 hour in 100 ppm solution of gibberellic acid and dried prior to testing in petri dishes. Furthermore, cuttings of creeping sage have been successfully rooted in a mist chamber. Out-plantings of this low-volume shrub can now be done on fuel-break and at other strategic fire control locations. - PSW.

The head firing of Southern plantations having only a 1-year accumulation of fuel has been shown to be a safe procedure for hazard reduction burning. This burning should not be attempted until the area has at least 80 percent crown closure. Burning also should not be done when relative humidities are below 20 percent because spotting in excess of 15 feet can then cause a control problem. - SE.

Slash burning season can be lengthened in westside Cascade forests. Present practice of burning slash in autumn is too restrictive from time, manpower, and smoke management standpoints. An analysis of climatic and fire-danger records showed that all westside Cascade forests have suitable slash burning conditions, from January through July at least. Such extension of the burning season would double or triple the time period in which slash burning could be done and the smoke dispersed. - PSW (6).

Coastal Alaska has fire potential--in spite of heavy rainfall. Heavy fuel concentrations, the existence of even-age stands, and old fire scars are reminders to avoid complacency in fire planning in wet Coastal Alaska. Most of the fires are man caused, and these tend to be clustered around populated and high-use areas. For the 12-year period (1956 through 1967) the annual average was 20 fires and 450 acres burned in Alaska's

National Forests, although 3,360 acres burned in 1959. Because most fires are caused by recreationists, smokers, and land-clearing and land-occupancy activities, fire prevention programs should be so oriented. - PNW (12).

Multiple electrical ignition is an effective and flexible method for touching-off prescribed burns where area ignition is required. This relatively simple technique allows for greater safety and more positive control, especially for igniting burns on steep, difficult slopes, than firing with torches or fusees. - PSW (17).

2. FIRE CONTROL METHODS AND SYSTEMS

How best to allocate available resources is a common problem in fire control and other forestry operations. The optimum or most efficient solution to the problem is best achieved by using complex mathematical techniques and computers. But now that simplified versions of these techniques have been developed, some allocation models can be effective without computing equipment. The use of two allocation models--transportation and assignment--is explained step by step in a report and illustrated with examples of their applications to typical fire control problems. - PSW (23).

Three years of study in the West show that a light helicopter can be flown safely at night provided the pilot and ground support crew are trained in the procedures, the helicopter is properly equipped, and the operation is well planned. The effectiveness of the system, however, can be hampered by smoke or smog. Moreover, the tendency for fire bosses to fly all permitted pilot hours during the daytime further limits practical use. - PSW.

Fire retardant viscosity table is updated. About 4 years ago, the Marsh funnel was modified so that the viscosity of all currently used forest fire retardants could be determined in the field. The data were obtained by comparing viscosity from the Brookfield Viscometer with the flow-through time for the Marsh funnel. Thus, "Marsh funnel time" serves as an inexpensive criterion of actual viscosity. The revised table includes all currently used retardants and is a handy guide where fire retardants are being mixed. - INT (27, 28).

Peat, moss, and humus fires are difficult to extinguish because normal application procedures do not get water into the fuel where it is needed. Conventional nozzles have a tendency to throw firebrands and to waste water because of runoff. A root-feeding nozzle, as used by tree surgeons, was modified for use with 1-1/2-inch national fire hose female thread adapted. In field tests by BLM, the device was very effective in controlling and mopping up deep-burning fires. - PNW (22).

Of 75 wetting agents sent for evaluation at Southern Forest Fire Laboratory, 30 have been approved for U.S. Forest Service use in

differing concentrations in water. Only six have been found suitable for use in ammonium phosphate solutions. - SE.

A high-capacity water pumping and distribution system, designed to control field-scale experimental fires, has been developed in the Lake States. On the first operational test, the water curtain was more than adequate in stopping a 50-acre headfire. The fire was set in a cutover jack pine stand containing 50 tons per acre of logging residue. Only minor crown scorch occurred on peripheral trees located downwind from the fire. There was no significant spotting over the curtain, and little mopup was needed. - NC.

A preliminary evaluation showed that diluted liquid concentrate type fire retardants on fuels in interior Alaska were about as effective as viscous materials. The reasons might be attributed to the following factors: all retardants were dropped from 100 feet or less altitude onto primary ground fuels; the diluted concentrate material contained a 30 percent higher salt content than the viscous ones; and perhaps more uniform fuel coating and deeper penetration into the fuel by the diluted concentrate also contributed to its relatively equal effectiveness. - INT.

The ammonium-based fire retardants, such as Phos-chek and Firetrol, are not toxic to livestock, as some cattlemen have suggested. A study conducted in California concluded that nitrate poisoning, which has killed cattle, can't be caused by the common forest fire retardants because they must first be converted to nitrates through nitrification. Since nitrification is a time-consuming process and occurs in the soil under aerobic conditions, the danger of nitrate poisoning is slight. - PSW.

3. FOREST FIRE SCIENCE

A graduate level program of research has been established by cooperative efforts of the University of Washington and the Forest Service. As a result, graduate students at the Master of Science and Ph. D. level for the first time may major in forest fire science and technology in an American university. In the cooperative efforts a Forest Service fire scientist and the University staffs in forestry, meteorology, and engineering have developed graduate programs leading to a Master of Forestry degree (for forest fire control managers), and Master of Science and Ph. D. degrees (for fire scientists). Options include: forest fire prevention, forest fire economics, forest fire physics and behavior, forest fire meteorology, forest fire and atmospheric pollution, and prescribed fire and forest land management. - PNW.

A mathematical model for computing fire spread and intensity has been completed. This model is being evaluated by the National Fire-Danger Rating System Project during the 1970 fire season. The equations developed for a homogeneous fuel bed in the absence of wind were modified to include the effect of wind and slope and apply them to a heterogeneous fuel bed of mixed particle sizes. A computer program has been supplied to the National Fire-Danger Rating Project. - INT (35).

Fire spread wave theory is confirmed in laboratory. An examination was made of the velocity and structure of some quasi-steady fire spread waves as they spread through and into arrays of cellulosic solid fuels. Experiments were conducted in a low speed combustion wind tunnel at the Northern Forest Fire Laboratory. The theory successfully predicted the structure of the reaction wave measured in the wind tunnel. These results will be useful in developing realistic models of the spread of forest fires. - INT.

Convection coefficient predicts fire spread. Experimental tests compared to mathematical computations showed radiant heat transfer accounted for no more than 40 percent of total heat flux required to maintain rate of spread. Use of a horizontal convective heat transfer coefficient allows prediction of spread of fire. These results will be useful in developing fire spread models. - INT (32).

Convergency and vorticity in a mass fire experiment were studied using an array of anemometers and a pulsed doppler radar. Principal flow feeding the fire came from high elevations. The fire was designed to induce rotation which took about 1 hour to develop. This helps explain the so-called "erratic behavior" on some disaster fires. - PSW (62).

The extensive aerospace literature was surveyed for results applicable to fire research. Computer programs were identified which modeled thermodynamics and physicochemical theories. These programs have been adapted to theoretical mass fire studies. - PSW.

Scientists in the Pacific Northwest have shown that height and perhaps other characteristics of understory vegetation can be measured with acceptable accuracy on 1:8,000, natural-color, aerial photography. Photography from earth-orbital satellites may be suitable for small-scale mapping of major fuel categories. This knowledge can be of value in fire planning and fire control activities. - PNW (56).

Vegetative measurements from the palmetto-gallberry type show that dry weight varies from 0.1 to 9.0 tons per acre, of which 92 to 100 percent is thinner than 1/4 inch. These results help explain why fire behavior in this fuel type is so responsive to changes in relative humidity. - SE.

Radioactive cotton bolls are grown for fire chemistry studies. Experiments are underway to obtain specifically labeled radiocellulose by introducing specifically-labeled glucose into maturing cotton bolls of greenhouse plants. Autoradiography has been used to determine the distribution of the radioactivity in the harvested bolls, and these results are being confirmed by radiochemistry. Next, nonradioactive bolls are put through the chemical degradation procedure so as to determine the position of the label when radiocellulose is obtained. This research will help unlock some of the secrets of the pyrolysis and combustion processes of cellulose, a fundamental building block of forest fuels. - PSW.

Laboratory burning experiments help explain numerous firebrands and show why more spot fires can occur on spring than on summer fires. The experiments used 5-gram freeze-dried and uniformly sized leaves of two species of Arizona chaparral. Phosphate phosphorous, a glow inhibitor, ranged in concentration from 2,450 ppm to 4,421 ppm, a ratio of nearly 1 to 2, lowest in late spring and highest in late summer. These results are particularly important for foresters planning prescribed burns in Arizona chaparral. - RM.

A new simplified fire behavior guide is being prepared for use by fireline supervisors. It is called, "This humidity business--what it is and how it is used in fire control." The guide describes the various means of expressing air moisture in laymen's terms, discusses the importance of relative humidity in fire behavior, and suggests ways to use relative humidity and dewpoint in fire control activities. - PSW.

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B. Improving Insect and Disease Control

1. LIFE HISTORY AND ECOLOGY OF INSECTS

a. Bark beetles

Controversy over the ban on use of DDT and the substitution of methoxychlor as an alternative in controlling the insect vectors of the Dutch elm disease has led to a search for effective alternatives. Scientists at Delaware, Ohio, are seeking chemical materials that are less hazardous in the environment. Also, they are working with promising biological control organisms such as the imported parasite Dendrosoter protuberans.--NE (28).

Predicting emergence of bark beetles is important in certain work involving the use of attractants. Regeneration of flight muscles to maximum size following egg laying and just prior to emergence offers a method for forecasting Black Hills parent beetle emergence.--RM (39).

Egg production by the Engelmann spruce beetle is apparently related to the status of infestation. The number of eggs produced during outbreaks is considerably higher than during low activity periods.--RM (27).

Mountain pine beetle infested jack and eastern white pines planted in an Idaho arboretum. This suggests that caution be exercised in seeking to breed Pinus strobus to native white pine, P. monticola, for the greater resistance to blister rust that P. strobus has, or in introducing new tree species to areas outside of their natural range.--INT (16).

Prediction of mountain pine beetle survival and the probability of tree loss in lodgepole pine stands can be made on the basis of food quantity and tree diameters. Adult survival ranged from 0 in trees with phloem 0.06 inch thick to 120 beetles per square foot of bark in trees with phloem 0.18 inch thick. Larger diameter trees were infested and killed first, the development of sizeable infestations depending upon diameter and phloem thickness of trees, stand density, and plot elevation.--INT (1, 7).

Large numbers of Ips avulsus and I. grandicollis were attracted to the fresh slash from summer thinning of loblolly pine in southeastern Tennessee. The resultant brood dispersed to old or low vigor trees outside of the thinned areas rather than attacking healthy residual trees. Thus, slash from summer thinnings may pose a hazard to stands of low vigor trees but is unlikely to be a serious threat to healthy stands.--PNW (29).

Laboratory studies have shown that over 80 percent of the spruce beetle parent adults emerge and are capable of attacking new host trees. This is of significance in determining the reproductive capacity of newly emerged brood adults and in timing control to account for both parent and brood beetles.--RM.

Several physiological changes take place in lightning-struck trees which explain why many of these trees are rapidly attacked and serve as focal points for southern pine and Ips engraver beetle infestations. Following the strike, changes in resin pressure and flow and the relative water content of the inner bark lower the physical resistance of the trees to attack. Similarly, changes in the carbohydrate content of the inner bark affect insect nutrition, trees with higher levels producing larger broods.--SO.

Control of bark beetles in forested areas valued primarily for scenery and recreation poses a special problem. Use of the California insect risk rating system in mature ponderosa pine stands in western Montana has shown that, although tree mortality was low over a 20-year period, beetle-killed trees were concentrated in high-risk classes. Thus, selective removal of such trees can reduce beetle damage.--INT.

b. Defoliators

Populations of Lymantria obfuscata on poplar and willow were reduced 91 to 99 percent at Sringagar and Kulu, India, in 1969 (PL-480). Factors responsible for egg, larval, and pupal mortality included failure to hatch, parasitism, predation, climatic influences, disease, and emergence failure.--WO.

Stands of western larch defoliated heavily for 4-10 years by the larch casebearer in northern Idaho contain dead and dying trees. Though wood borers and root rots contribute to weakened tree mortality, little evidence of these organisms appeared in the stands. There was no indication that site factors contributed to deterioration. Although the larch casebearer was not confirmed as the sole cause of tree mortality, the evidence strongly suggested that it was responsible for weakening and killing trees.--INT (50).

Defoliation by the black-headed budworm, Acleris variana (Fern.), is more severe on hemlock than spruce, because less foliage is produced by hemlock, new growth is available before that of spruce, and there are differences in the feeding behavior of first- and second-instar larvae on each of the hosts.--PNW (57).

No differences in rate of development from egg to adult occurred in two successive generations of black-headed budworm reared on hemlock and spruce in the laboratory. Female budworms had a longer life span (88 days) than males (77 days) on both hosts.--PNW (56).

Lateness of bud burst in Douglas-fir was found to be correlated with reduced intensity of infestation by a complex of needlemining midges (Contarinia spp.). Genetic manipulation of planting stock should reduce the intensity of midge infestation and solve the problem of timing chemical sprays.--PNW (35).

Heavy defoliation by the phantom hemlock looper killed understory reproduction and small trees; larger trees suffered top damage and reduced radial growth. The insect had a 1-year life cycle, overwintering in the egg stage on Douglas-fir needles. A polyhedrosis virus drastically reduced looper populations in 1966.--PNW (59).

c. Shoot and tip-feeding insects

Damage by the white-pine weevil varied with density of hardwood cover and ground conditions. Least damage occurred to pines under heavy shade.--SE (22).

Differences in sound pattern were noted between males and females of both Pissodes strobi and P. approximatus but not between the species. There is growing evidence that these two insects are the same species.--SE (21).

The southwestern pine tip moth, Rhyacionia neomexicana, seriously affects terminal and lateral growth of natural regeneration and planted ponderosa pines. Adult moths emerge in early April and deposit their eggs on the needles. Larvae feed until mid-July, pupate, and second-generation moths emerge in August. Several parasites and predators feed on the tip moth larvae and pupae.--RM.

Characters for determining the sex of Rhyacionia pupae include pupal size and shape, number of abdominal segments with a finely textured band on the lower third of their surfaces, and location of the genital openings.--SE (64).

Exoteleia burkei has been found boring in the developing shoots of knobcone pines in California for the first time. Generally, infestations were confined to single larval mines in shoots and needle bases but, rarely, multiple infestations were found. Damage resulted in growth loss and stem distortion.--RM (48).

d. Sucking insects

Tuliptree scale attacks on seedlings, saplings, and poletimber result in distorted, low-vigor, or dead trees. The scale has a single generation per year. Dispersal is via windblown crawlers. Heaviest feeding occurs during June through August. Larvae of a predaceous moth, a ladybird beetle, and a parasitic syrphid fly reduce scale populations but their activity is held in check by honeydew-feeding ants. Ice, snow, and temperature extremes cause scale mortality.--NE (4).

The moth Acrobasis comptoniella can severely defoliate sweet-fern, but it is susceptible to 19 species of parasites. Elimination of sweet-fern, the alternate host of the Saratoga spittlebug, by this and other specific agents could reduce spittlebug damage in pine planatations. The effective use of such beneficial insects, however, requires more knowledge of their behavior and ecology.--NC (62).

In India (PL-480), life tables constructed for the balsam woolly aphid showed that predators were generally more effective in spot attacks on silver fir stems and twigs than in mass-attacked areas. Analyses suggested that the death rate of aphids due to predators alone was very low compared with other factors such as severe winter conditions, rain, and hailstorms.--WO.

Analysis of radial growth in Fraser fir protected by chemical means from reinfestation by balsam woolly aphid indicated that growth trends conformed to annual precipitation patterns during each of seven growing seasons. This was true for trees with one to three redwood rings resulting from previous aphid feeding, as well as those with no redwood formation. This indicates that there is no holdover effect from aphid infestation.--SE.

Many low-growing plants or trees serve as alternate hosts for the Saratoga spittlebug nymph, but sweet-fern is the only plant whose abundance is directly correlated with degree of spittlebug injury in the Lake States. By determining the percentage of ground cover occupied by sweet-fern and other suitable hosts (as a group) it is possible to predict the potential severity of insect injury in red pine plantations.--NC.

e. Cone and seed insects

The economic impact of seed-destroying insects is greatest in high-value seed orchards of genetically superior trees. The concept and justification for insect control in seed orchards, therefore, are different than those for natural forested areas.--SE (33).

The flower thrips, Gnothothrips fuscus, causes serious losses in slash pine seed orchards. A heavy infestation in northeastern Florida resulted in a 46 percent loss of female flowers. Of the remaining conelets, 28 percent had thrips injury on individual cone scales. Such losses are intolerable in seed orchards managed for maximum yield of high-value, genetically superior seed.--SE (10).

Examination of balsam fir seed from Pennsylvania, bracted balsam fir seed from Virginia and West Virginia, and Fraser fir seed from North Carolina revealed that the seed parasite Megastigmus specularis infests seed along the entire Appalachian Mountain range.--SE (47).

Weevils cause far more damage to acorns than any other insects. Curculio sp. and Conotrachelus sp. take the heaviest toll each year. However, the impact of acorn losses on natural regeneration of oaks is unknown.--NE (17).

Detailed morphological and taxonomic characteristics of the genus Curculio L. have been published for 27 species occurring in the United States and Canada. Information on distribution, biology, and host and species ranges was also summarized.--NE (18).

Under controlled conditions in the laboratory, adults of the acorn weevil Curculio strictus congregate on the foliage of chestnut oak in June where they mate and feed for periods of 90 to 120 days before they begin destroying the acorn crop.--NE.

Insect damage to direct-seeded western white pine was investigated in prescribed burn areas in north central Idaho. Fall-sown, treated seeds were least affected by insects; spring-sown, untreated seeds were the most susceptible. Seeding of areas during theyear of the prescribed burn resulted in the least amount of insect damage.--INT (25).

The short-tailed cricket, a serious pest of southern pine seeds and seedlings, lays eggs in burrows excavated 12 to 16 inches below ground. Young nymphs usually disperse after the parent female dies. New records of parasites, predators, and inquilines have been obtained.--SO (55).

Galls on branches of red pine caused by the pine gall weevil, though unsightly, have little or no influence on the tree's capacity to produce cones.--NC (32).

Insects are the leading cause of cone losses during the first and second year of cone development in Lake States red pine seed-production areas. The Zimmerman pine moth, jack-pine budworm, and red pine cone beetle

cause major losses during the first year. Overall insect-caused losses during the 2-year cone development period account for an average of 80 percent of the potential crop.--NC.

f. Root and root-collar feeders

Keys, descriptions, and biological notes have been developed for eight species and two subspecies of aphids which are known to be, or are strongly suspected of being, associated with roots of conifers in North America.--WO (45).

g. Wood products insects

A PL 480-sponsored survey of wood-destroying termites was conducted at Jammu and Kashmir, India. Major species collected in the Jammu region included Heterotermes indicola, Odontotermes bhagwati, O. lokanandi, O. gurdaspurensis, O. parvidens, and O. obesus. A scavenger termite, Archotermopsis deodarae was found in Kashmir.--WO.

Pinworm and grub damage in white and red oaks results in losses conservatively estimated at 20 million dollars a year. Such damage does not result from direct tree killing but rather from degrade in sawn products. The landowner has two choices: accept losses of up to 1/4 of the usable volume or control these pests through improved management.--NE (12).

The cedar tree borer, Semanotus ligneus amplus, and the fir tree borer, S. litligiosus, will crossmate, and females of reciprocal crosses produce viable eggs. This indicates that the cedar and fir tree borer populations may be a part of the same species complex.--PNW (58).

The incidence of trunk borers in planted cottonwood has been determined for trees ranging from 1 to 12 years of age. The clearwing borers, Paranthrene dollii, P. tricincta, and Oberea delangi were most common during the first 3 years after establishment. The large cottonwood borer attacked some first year plantings cutting them off at the ground line. The poplar borer, Saperda calcarata. began its attacks in the third year and increased in abundance with age.--SO.

h. Mathematical models

The essence of the experimental components approach is that the processes of experimentation and mathematical model construction are conducted as two interlocking parts of an integrated program. A systems model is constructed which can be used to simulate the process on a computer.--NE (54).

The fall webworm has been used to describe the "life-table," "key-factor," and "process" approaches to the study of insect population dynamics.--NE (36).

A properly constructed mathematical model can provide all the information needed for understanding a biological system, predicting its behavior over time, and regulating it purposefully. Such a model will provide, too, the best possible guide to systems research by focusing effort on the measurement of important parameters.--NE (37).

Deterministic models are highly useful in the study of average behavior of insects. Stochastic models, with their embedded chance mechanisms, appear to be better suited to the study of population explosions and extinctions.--NE (6).

Knowledge of the insect population system is essential for population regulation. Lowering the mean density level, reducing amplitude of the oscillations, extending the periods between peaks of abundance, or any combination of these can be effective in population regulation.--NE (52).

Life tables provide a basis for analyzing the relative importance of the interacting destructive and constructive forces operating on forest stand productivity and usefulness. Life-table data for forest stands may be analyzed to reveal the critical age intervals and the factors or agents most important in determining yield and value. These data can also augment analytical schemes of forest regulation now in use.--NE (51).

Sampling errors in estimating insect population numbers, mortality rates, etc., can greatly distort judgments of the validity of these estimates and the reliability of the mathematical models developed thus far for analysis of life-table data.--NE (63).

Analyses of sparse and dense gypsy moth populations through sets of life tables identified the age interval survival rates most closely related to changes in population numbers and the mortality causing factors related to these survival rates. Models were developed for these agents or factors and successfully used to describe or analyze long-range population trends.--NE (5).

The population density of certain insects affects their color, morphology, dispersal ability, and reproductive potential; therefore, it is a factor which requires examination in population dynamics research.--SE (14).

i. Miscellaneous

Gall wasps (Eurytoma sp.) infest several species of pines in California. Damage is restricted to small stems and is characterized by external swelling and internal "bird's-eye" patterns.--PSW (49).

Over 30 species of insects and mites occur on 23 species of trees and shrubs used in North Dakota shelterbelt plantings. Of these, the caragana blister beetle, woolly elm aphid, boxelder twig borer, poplar petiole gall aphid, fall cankerworm, and spur-throated grasshopper are most prevalent.--RM (26).

The role of forest entomology in the total forest management process is now being emphasized. The forest resource manager and administrator cannot maximize or optimize productivity, value, and usefulness of the total resouce without minimizing, or at least regulating, losses and disturbances by insects--and all other destructive agents.--WO (53).

2. INSECT PHYSIOLOGY, NUTRITION, AND REARING

In India, serological studies (PL-480) of Lymantria obfuscata and Porthetria dispar were completed; they confirmed the validity of the two as distinct species.--WO.

Two feeding stimulants for the smaller European elm bark beetle were isolated from elm bark extracts. These were identified as lupeyl cerotate and catechin xyloside. Bioassays indicated that these compounds accounted for most of the feeding stimulation in the beetle.--WO (72).

Adults of both sexes of Dioryctria abietella responded more to odors from the basal 1/3 of slash pine conelets than to other portions of the cones. This identifies where the eggs may actually be laid.--SE (69).

Injection of bromolysergic acid diethylamide blocked the neuromuscular junction, affecting both the nerve and muscular activity of wax moth larvae. Knowledge of neuromuscular transmissions in insects will help us in determining mode of action of applied chemicals.--SE (67).

Bromolysergic acid diethylamide produced virtually complete paralysis of the somatic musculature of 5th instar larvae of the wax moth. Some circulatory and digestive activities were maintained during paralysis. This permitted study of certain life processes under inactive body conditions.--SE (68).

A wheat germ diet was developed for rearing pales weevil larvae from the egg stage. Approximately 50 percent survived. The pupation rate, however, was seriously reduced when the weevils were reared in small plastic cups as opposed to plastic petri dishes.--SE (79).

Elm spanworm adults developing from larvae fed entirely on tender host foliage produced more viable eggs than those fed on increasingly older, toughened foliage. Hickory-reared spanworms had much greater pupal weight and fecundity, shorter development time, and larger 5th instar head capsules than oak-reared spanworms.--SE (74).

The size of the compound eyes of the elm spanworm is a secondary sex characteristic--males having larger eyes than females. Food also influences eye size.--SE (73).

Results of a serological comparison of Pissodes strobi and P. approximatus suggest that the two populations are not separate species.--NE (78).

Changes in the carbohydrate content of the inner bark of loblolly pine were caused by microorganisms associated with the female southern pine beetle. Knowledge of chemical changes caused by associated fungi will be used in understanding their influence upon beetle nutrition and development.--SO (71).

Penicillium implicatum isolated from black turpentine beetle galleries was found to be antagonistic to blue stain organisms commonly associated with various bark beetles. These findings suggest further research on the use of anti-fungal organisms to disrupt the bark beetle-nutrition cycle.--SO (70).

Examination of emerging mountain pine beetles, which included both parent and brood females, from field-infested ponderosa pines, showed that 15 percent of the females had already been mated. Two percent of the brood females contained sperm. Thus, it cannot be assumed that newly emerged females are unmated and useable as such in experiments.--RM (38).

Artificial diets have been successfully used for rearing the red oak borer. Adults were obtained from larvae on wheat-germ-based diets in as little as 6-7 months. Fecundity of adult females, however, was somewhat lower than that of field-collected beetles, possibly as a result of a vitamin deficiency in the diet.--NE.

Fresh inner bark of loblolly pine contains oleic, linoleic, palmitic, and linolenic acids with traces of stearic, myristic, and a few other unidentified fatty acids. The two major sterols are sitosterol and campesterol.--SE.

The flight and sexual behavior of Dioryctria abietella has been determined by means of automatic electrostatic and photographic techniques in the laboratory. Night movement coincides with sexual activity, beginning shortly after the onset of darkness and reaching a peak approximately 9 hours later.--SE.

The major fatty acid components of the native subterranean termite, Reticulitermes flavipes, are palmitic, palmitoleic, stearic, oleic, and linoleic acids. The patterns are generally similar but there are differences in fatty acid composition among termite colonies. Also, fatty acid composition differs when termites are fed sound or decayed wood.--SO.

Comparison of free- and protein-bound amino acid content of sound wood and powder-post beetle (Lyctus planicollis) frass from infested pecan has shown that the larvae deplete both types of acids indiscriminately. Aspartic and glutamic acids are the predominant forms in both sound wood and frass. There is no evidence that any particular amino acids are utilized in preference to others.--SO.

Female pronotal mycangia and male pseudomycangia were cultured to determine the relative abundance of microorganisms associated with these

structures in the southern pine beetle. The predominant fungi in females were a basidiomycete and Candida sp. Yeasts were common associates of both organisms and two Penicillium spp. were found in a few mycangia. Yeasts were the predominant organism in pseudomycangia. The blue stain, Ceratocystis minor, was rarely isolated.--SO.

3. BIOLOGICAL CONTROL OF INSECTS

a. Invertebrate parasites and predators

Thirty-six species of parasitoid mites have been found associated with Dendroctonus and Ips bark beetles attacking pines in the southeastern United States. Keys and figures have been developed for identifying the adult stages. A catalogue of taxonomical, biological, and ecological literature has been developed for each previously known species. Listings of species were based on collections from the bark surface, inner bark, or associated with bark-inhabiting beetles.--WO (87).

Parasitism of pales weevil larvae by three nematode strains (Neoaplectana spp.) ranged from 31 to 69 percent in the laboratory. At times, it may be feasible to use nematodes to control selected insect pests.--SE (81).

Laboratory studies of the feeding behavior of Aphidecta obliterata indicated that it consumed an average of 1,853 balsam woolly aphid eggs per larva. Fourth stage larvae consumed more eggs per capita than the first three stages combined. Predation was reduced when predator density increased.--SE (93).

Color is an accurate and rapid means of distinguishing most stages of the introduced predator Aphidecta obliterata and two native coccinellids that also prey on the balsam woolly aphid. A. obliterata sex can be determined by observing differences in adult head markings and length.--SE (94).

Field and laboratory brood development time, egg laying efficiency, and parasitism rates have been determined for Dendrosoter protuberans, an introduced larval parasite of the smaller European elm bark beetle. The role of three indigenous parasites, commonly associated with the bark beetle, has also been investigated.--NE (82).

In India (PL-480), it was found that Cremastus (Trathala) sp. and Elachertus nigritulus were the dominant parasites affecting Dioryctria abietella, D. sylvestrella, and D. castanea during March through May. Another species, Trichomma sp., was recovered from infested hosts in the laboratory.--WO.

Polish studies (PL-480) showed that several parasites tend to infest European pine shoot moth previously infested by other species. This was most marked in parasitism by Temelucha interruptor and Pristomerus orbitalis. Stimulation for the selection of previously infested hosts was not conclusively associated with attractants released by primary parasites. Host injury and excrement apparently played an important role in attracting the parasites.--WO (83).

Trichogramma spp. played a significant role in the population dynamics of European pine shoot moth in Poland. However, degree of parasitism varied in space and over time, populations in the same environment tending to remain in spatial isolation from those in other environments. Preliminary evaluation of spiders as predators indicated that certain species seemed predisposed to capturing shoot moth larvae. Effectiveness appeared to be related to the density of the host.--WO.

Egg mortality of the spruce aphid Adelges knucheli in Pakistan (PL-480) varied from 22 to 41 percent in 1969, and averaged 37 percent. Lower populations of predators (Tetraphleps abdulghanii and Leucopis sp. (orbitalis group)), than in 1968, were associated with decreased egg mortality. Systematic field studies of nymphal predation indicated that predators had little effect on host populations in this stage. The severe winter of 1968-69 caused heavy mortality of host insects which, in turn, affected the predator population.--WO.

In Pakistan (PL-480), predators destroyed 6 percent of the eggs deposited by Adelges joshii in August. Forty-six percent of the females and 61 percent of the eggs were destroyed by predators in a mixed infestation of A. knucheli and A. joshii at Malam Jaba, Pakistan. Comparisons of predation of A. joshii occurring under lichens and bryophytes versus that in cracks, crevices, and open areas revealed that more severe predation occurred in the more exposed positions.--WO.

An inundative release of the parasite Itoplectis quadricingulatus was tested as a means for reducing European pine shoot moth pupal populations in a 40-acre infestation. Approximately 30 percent of the host pupae were killed, demonstrating the feasibility of parasite releases in an integrated control program. Host population reduction compared favorably with that expected from a release of similar numbers of sterile shoot moth males.--PNW.

The interaction of two shoot moth parasites, Apechthis ontario and Itoplectis quadricingulatus, was determined by releasing equal numbers of adult females in laboratory cages provided with host insects and varying light intensities. Rapid maturation and adaptation to higher light intensities of I. quadricingulatus permitted it to predominate at the beginning of the experiment. A. ontario predominated later in the experiment because of its greater longevity. Total host mortality was reduced compared to situations where the parasites operated alone. These results support the approach of introducing more than one parasite species to control forest pests.--PNW.

Sixteen species of parasites attack the black-headed budworm in Alaska. The egg parasite Trichogramma minutum causes up to 22 percent mortality. Four larval parasites kill up to 72 percent of the larvae in single populations. Two pupal parasites occur in 10 to 31 percent of the pupae.--PNW.

Eight species of ichneumonid parasites affect the pupae of the western hemlock looper in southeast Alaska. The most common species include Aoplus velox occidentalis, Pimpla pedalis, P. aquilonia, and Apechthis ontario.--PNW.

Twenty-three different insect parasites have been recovered from the large aspen tortrix in interior Alaska. Phaeogenes hariolus and Glypta fumiferanae were the most prevalent species.--PNW.

Adults of the predator Laphria gilva capture emerging mountain pine beetles in flight. The flies rest on beetle-infested trees and initiate mating, egg laying, and predation from this location. Very little mortality results from their activity.--RM.

Two internal parasitic nematodes have been recovered from Reticulifermes flavipes. One is thought to have an important effect on protozoans normally occupying the gut of this termite. The other species occurred in the head of the host.--RM.

Approximately 25 percent of the adults of southern pine beetle, black turpentine beetle, and the three southern Ips engraver beetles collected in the Southeastern States were found to be infested with nematodes. Two genera, Contortylenchus and Parasitylenchus, commonly reduce the egg production of their hosts by at least 50 percent.--RM.

A complex of parasites and predators attacking southern pine beetle in five North Carolina infestations accounted for an 18 percent reduction in brood over a 4-year period. Mortality was higher at midbole in shortleaf pine than in Virginia or loblolly pines. Of the bark beetles killed during summer and fall, clerids were responsible for 45 percent of the mortality.--SE.

b. Vertebrate predators

Five species of woodpeckers preyed on 14 species of insect borers infesting trunks and branches of living hardwood trees in west-central Mississippi. Predation ranged from approximately 13 to 86 percent depending on the size of the stem, location and density of the borer larvae, and the availability of alternate food supplies. In general, predation was greater on smaller diameter stems and during the dormant season.--SO (92).

Resident populations of three species of woodpeckers exhibited a graded response to bark beetles attracted to 10 acres of fire-killed subalpine forest in northern Colorado. Evidence suggested that the graded response was related to the foraging habits of each species of woodpecker.--RM (84).

A 4-year survey of parasites and predators of the southern pine beetle in North Carolina showed that woodpeckers accounted for 65 percent of the beetles killed during the winter and spring months.--SE.

c. Insect pathogens

The polyhedrosis virus of the European pine sawfly has been mass-produced and the polyhedra extracted in an 8-week period at a cost of approximately one cent per sawfly larva.--NE (89).

A new strain of the yeast Candida zeylanoides was isolated from a laboratory strain larva of the Douglas-fir tussock moth. Infectivity tests suggested that the yeast was capable of causing a fatal disease at high inoculation doses. Yeasts are known to invade the host organism when its general resistance is lowered or altered; it is possible that insects continuously reared in the laboratory on artificial diets may have low resistance to certain internal pathogens.--PNW (85).

PL-480 investigations in four different regions in Yugoslavia revealed that gypsy moth viruses from Slovenia were more pathogenic than those from Serbia, Macedonia, or Dalmatia. Viruses from the Soviet Union and Japan were more pathogenic to gypsy moth caterpillars than those from the United States.--WO.

Bacteria of the genera Streptococcus, Serratia, Aerobacter, and Proteus have been isolated from field-collected, diseased gypsy moth larvae. Laboratory assays have shown that these organisms are pathogenic.--NE.

A 4-year survey of pathogens affecting southern pine beetle in five infestation areas in North Carolina has been completed. Fungi and bacteria destroyed 26 percent of the broods over the period. More beetles were killed at midbole in shortleaf pine than in Virginia and loblolly pines. Mortality was greatest during the winter as a result of combined disease and predator affects.--SE.

Five genera of internal bacteria have been recovered from healthy southern pine beetle larvae and adults. These included Serratia marcescens, Serratia sp., Alcaligenes sp., Aerobacter sp., Pseudomonas sp., Bacillus megaterium, and B. cereus.--SE.

4. CHEMICAL CONTROL OF INSECTS

a. Insecticides

A series of studies on fate of insecticide chemicals in relation to nonpersistence and insect species specificity have led to a better understanding of: 1) metabolism and biochemical behavior of carbamates, rotenone, allethrin, and several other pyrethroids, several methylenedioxyphenyl synergists, and certain respiratory uncouplers; 2) photodegradation of certain carbamates, pyrethroids, and respiratory uncouplers; 3) binding sites of rotenone, piericidin A, and coenzyme Q in the respiratory chain components; 4) the biochemical bases for lesions leading to teratogenesis induced by certain organophosphorus compounds; 5) the toxicity, activity, and mode of action of certain insecticide chemicals that uncouple oxidative

phosphorylation; 6) factors involved in resistance and in the biochemical genetics of resistance; and 7) synthesis and testing of "pyrethroidlike" compounds having nonclassical structures.--WO.

Chemical control studies in Yugoslavia (PL-480) showed that a 0.1 percent DDVP formulation was 100 percent effective against overwintering larvae of the poplar leaf roller. Parathion, phosphamidon, and dimethoate formulations also provided satisfactory control of larvae feeding in leaves, stems, and terminal shoots.--WO.

Geographic location, pesticide formulation, application techniques, weather, tree species, and site are among the factors that seed orchard managers must consider in making control decisions. There is considerable merit in using an integrated approach involving cultural, biological, and chemical control means rather than relying on a single pesticide or method.--SE (118).

Zectran, a nonpersistent carbamate insecticide, has shown a higher degree of selectivity for killing the western budworm than any other chemical tested to date. Zectran and its main active metabolites are readily broken down by sunlight and in plant and animal systems. All studies to date indicate that Zectran can be effectively and safely used in the field.--PSW (108).

Zectran is currently being considered for operational use in controlling the western budworm and related forest defoliators. Though it has a low dermal toxicity to mammals--of most concern for field use--it does have a very high oral toxicity. Placing an acetyl group on the Zectran molecule does not greatly alter its toxic effect on western budworm, but virtually eliminates oral toxicity in mice.--PSW (107).

Larvae of the western budworm show characteristic symptoms of hypersensitivity, reflex bleeding, and regurgitation when treated with Lannate, a carbamate insecticide. The fluids that are produced increase mortality.--PSW (105).

The potential of "surface" and "tissue" (subsurface) deposits of various synthetic, organic insecticides (DDT, dieldrin, dinitrocresol, endrin, heptachlor, lindane) has been investigated in the laboratory and field. Each insecticide was characterized by spontaneous crystallization of a unique form after applications as solutions. Lindane and dieldrin subsurface deposits were consistently more effective than surface deposits in killing beetles in infested logs and in protecting green uninfested logs.--PSW (106).

Chlorinated hydrocarbon insecticides applied to the soil to control subterranean termites have moved very slightly after 10 to 20 years of weathering in field study areas in southern Mississippi. Aldrin, chlordane, dieldrin, and heptachlor continue to give 100 percent control of termites after 19, 20, 19, and 16 years, respectively.--SO (112).

The addition of chlorinated hydrocarbon insecticides to wood treated with preservatives will prevent subterranean termite tubing. Both pentachlorophenol and Wolman salts were tubed over when the preservative was used alone.--SO (97).

One percent aldrin formulations applied to seedlings at planting time provided adequate white grub control for two growing seasons. Liquid formulations were dispensed from a planting machine or with a backpack sprayer. The granular form was applied from a planting machine.--NC.

Treatment of alternate host plants with the granular systemics Baygon, Furadan, Temik, and Thimet reduced Saratoga spittlebug populations 94 to 100 percent. Materials were applied at 1/2, 1, 2, and 3 pounds per acre.--NC.

A new stabilized formulation of pyrethrins has been field-tested against larvae of the western hemlock looper. Applied from a helicopter, the insecticide achieved effective initial knockdown and ultimate mortality. However, degree of direct exposure of the insect at time of spraying materially influenced the degree of control.--PNW.

Fifty-five insecticides were tested for their toxicity to larvae of the Douglas-fir tussock moth. The 10 most active insecticides in descending order of average toxicity at LD_{90} were pyrethrins, Dursban, Zectran, dichlorvos, GC 6506, Metacil, Neopynamin, allethrin, Bayer 37289, and DDT.--PSW.

Aerosol formulations of six insecticides were tested in the laboratory against larch casebearer larvae. All six were highly toxic at the equivalent of 1.5 oz./acre. In decreasing order of contact toxicity at LD_{90}, they included Zectran, malathion, Sumithion, pyrethrins, Metacil, and Gardona.--PSW.

The contact toxicity of insecticides applied to 4th instar fall cankerworm larvae, reared on an artificial diet, showed the following decreasing order of toxicity at LD_{90}: pyrethrins, Zectran, Gardona, p,p'-DDT, malathion, and carbaryl. Except for carbaryl, which has been successfully field tested, the other materials are candidates for field trials.--PSW.

Laser holography has been used to study the characteristics and behavior of insecticide aerosols. It allowed study of spray particles as they came in contact with western budworm larvae and their silk webbing. Among five solvents, there was significant evaporation of relatively nonvolatile solvents, particularly when the droplets were below 40 microns in diameter.--PSW.

Sublethal doses of Lannate applied to western budworm produce a number of effects resembling those of juvenile hormone. These include delay in pupation, increased rate of weight gain, and increased incidence of pupal abnormalities.--PSW.

Low doses of Lannate topically applied to 6th instar larvae of western budworm caused hyperactivity, regurgitation, bleeding, and prostration which resulted in a loss of hemolymph and gut fluid equaling 28 percent of the body weight. Treated larvae also showed lower pupal weights and reduced fertility as adults.--PSW.

Lindane and cacodylic acid were tested against the mountain pine beetle in the central Rocky Mountains. Lindane was as effective as the currently used ethylene dibromide and was easier to apply. Cacodylic acid applied shortly after mass attack was highly effective but timing of application was highly critical.--RM.

Stem implants of dicrotophos (Bidrin) at the rate of 5 grams/inch of tree diameter gave better than 90 percent control of Dioryctria coneworms when applied in February, March, or April. The same dosage rate provided 88 percent control of Laspeyresia anaranjada when implanted 4 to 6 weeks prior to time of maximum larval entry into maturing cones. These findings will permit extension of the period of cone protection and help minimize first-year cone losses due to early-season coneworm attacks.--SE.

Absorption of two percent concentrations of the systemic insecticide Monitor by the roots and subsequent translocation into the stem and new terminal growth of loblolly pine seedlings resulted in 100 percent pales weevil mortality 5 days after treatment. Biologically effective concentrations of the material were not available in the plants 90 days after application.--SE.

Analyses for chemical residues of organochlorines, applied to soils for termite control 17 to 21 years ago, have shown that these materials have moved only a few inches horizontally and vertically from the area where they were applied.--SO.

Laboratory tests have shown that rates of aldrin, chlordane, dieldrin, and heptachlor recommended for native subterranean termite control are less effective against the imported Formosan termite. It may be necessary to double the rates to effect control.--SO.

b. Chemosterilants and feeding deterrents-repellents

Two organometallic compounds, fentin acetate and fentin hydroxide, at three concentrations, were investigated as feeding deterrents to the pales weevil. Feeding was significantly reduced by both compounds at the 1 percent concentration, but not at lesser concentrations.--SE (113).

Male shoot moths were completely sterilized by topical application of 15 micrograms of tepa, without adverse effects on mating ability or longevity. Females needed higher doses of tepa to ensure sterility. Sterility in males was achieved by irradiating 11-day-old pupae with 26K rads from a $Cobalt^{60}$ source. Longevity and mating ability were not adversely affected at doses up to 35K rads. Female fecundity was reduced in direct proportion to the dose applied to the male.--WO.

Tepa influences the protein levels in the hemolymph, fat bodies, eyes, and testes of male spruce budworm larvae. Changes in the developing sperm result in steril gametes.--NC (80).

c. Natural products

The pales weevil responds to an attractant present in cut loblolly pine stems. Bioassays of purified extracts showed that the monoterpenoids, eugenol, anethole, and d-α-pinene were attractive to the insect. D-α-pinene makes up a large portion of pine oleoresin which may explain the attractiveness of freshly cut stumps to the weevil.--SE (114).

A portable air-pressure tank was adapted to deliver a continuous flow of air containing volatile substances into the air. Attractants were released inside a wire mesh cylinder coated with sticky material mounted on a pipe standard. This delivery-trapping system was used successfully for field evaluations of attractants of the California five-spined Ips and western pine beetle.--PSW (98).

A mixture of the western pine beetle attractant exo-brevicomin with frontalin and myrcene is more attractive to the insect than any other chemicals, singly or in combination. The attractant mixture is potentially very useful for the manipulation of bark beetle populations.--PSW (99).

Field studies of the aggregating behavior of the smaller European elm bark beetle revealed that significant numbers of flying beetles of both sexes were attracted to elm bolts infested with virgin females. Since wild populations also appear to respond to a primary attractant produced by elm tissue decay (Dutch elm diseased trees), it is apparent that the attractant produced by tunneling virgin females stimulates mass attacks.--NE.

Crude ether extracts from white fir inner bark sawdust were found to be attractive to both sexes of Scolytus ventralis in forced-air and arrestment-type laboratory olfactometers. Serial dilutions of the extract evoked arrestment responses equaling those of equvalent weights of whole sawdust, indicating the efficiency of the extraction technique.--PSW.

Attractants produced by attacking male Ips grandicollis were not very effective in attracting released, marked beetles. Bolts which were mass attacked lost their attractiveness to responding insects when attacks exceeded 27 per square foot of bark. Since more beetles attacked bolts placed outside the beetle-producing area than those within, this suggested that a dispersal flight was needed before the insects would respond to attraction centers.--SE (104).

The termite trail-following substance of Reticulitermes virginicus has been isolated and purified from wood infested by the insect and from wood infected with the fungus Lenzites trabea. The active component of the trail-following substance from the termite appeared to be identical with that from the fungus-infected wood. Thus, the insect may be attracted to fungus-infected wood.--WO (31).

5. HOST RESISTANCE TO INSECTS AND TREE PHYSIOLOGY

In India (PL-480), a total of 240 blocks from 38 different tree species were tested for relative natural resistance to attack by Microcerotermes beesoni. Seventy blocks were tested with Neotermes bosei. Cedrus deodara was the most resistant to M. beesoni and N. bosei attacks.--WO.

Feeding preference tests at Louisiana State University revealed that sapwood was less resistant to Formosan termite feeding than heartwood. This was particularly true for coniferous species and was less pronounced for hardwood species. Of the 23 host species tested, loblolly pine and Douglas-fir were the most susceptible to feeding damage; western cedar was the most resistant.--WO.

Beetle-infested trees decline in vigor as a result of the interruption of normal water translocation and metabolism. The accurate assessment of xylem sap pressure is the single most important tree-measured function for evaluating water status. Xylem sap pressure in uninfested trees varies with respect to the availability of soil water and to potential evapo-transpiration. Water status and relative transpiration data are also important in understanding leaf temperatures and energy exchange with respect to tree vigor. This is important in conducting and interpreting airborne thermal detection (previsual) surveys of beetle-infested trees.--PSW (123).

Success of forced attacks of western pine beetle on ponderosa pines damaged by crown removal was influenced by resin quantity, resin quality, and beetle attack density. Individual monoterpene components of ponderosa pine resin adversely affected beetle success in the following decreasing order: limonene, 3-carene, and B-pinene. Trees with as little as 25 percent limonene were relatively resistant to western pine beetle attacks.--PSW (121).

Loblolly pines subjected to drought and flooding showed a marked increase in reducing sugars and total carbohydrates and an approximate equivalent decrease in starch. The increase in sugars apparently was primarily the result of a decrease in growth rate. These results broaden the base for further research on the hazards of moisture stress in relation to stand susceptibility to bark beetle attack.--SO (119).

Lodgepole pine foliage from different sources varied significantly in susceptibility to attack by the lodgepole needle miner. High tree resistance was associated with trees growing on poorly drained, moist sites and the occurrence of certain volatile oils in the foliage. By developing cultural practices which favor the occurrence of resistant trees in the stand, it may be possible to prevent destructive outbreaks of the needle miner.--PNW (122).

Correlations of stand conditions and tree responses with southern pine beetle activity in southcentral Louisiana pine forests indicate that land managers should manipulate stand conditions so as to minimize bark beetle caused losses. Such practices include altering stand density, removing high risk trees, and altering drainage conditions. - SO.

6. INSECT SAMPLING AND SURVEY METHODS

A method has been developed for sampling balsam woolly aphid on Fraser fir. Precision is usually within ±10 percent of the mean. The greatest proportion of variance occurs within trees and is minimized by stratifying samples by levels within trees. - SE (126).

A multistage probability sampling system, incorporating visual observation, sample strip color photography and ground visits, provided a reliable means for detecting and evaluating ponderosa pine mortality caused by the Black Hills beetle. - PSW (131).

A 1:7,920 scale is necessary to detect small bark beetle infestations with the greatest accuracy. Photographs should be taken after the middle of August. There seems to be no real difference between normal color and infrared color films for detecting infestations. A 15-channel optical-mechanical scanner is useful for distinguishing between "old kill," faded infested trees, and nonfaded (previsual) infested trees. - PSW (132).

Stratifying cubic volume in forest stands on non-stereo and stereo photography in double sampling designs was compared by computer simulation techniques in a study in North Carolina. Non-stereo photo techniques reduced the variance of mean volume per acre estimates and increased sampling efficiency over ground sampling, but not enough to justify changing present procedures. - PSW (125).

Reliable quantitative data in sampling scarce insects are very difficult to obtain. Some problems associated with the sampling of scarce insects include measurement of population numbers, identification of mortality factors, and the effects of destructive sampling itself. - NE (134).

Defoliation of Douglas-fir and white fir by the western budworm can be estimated by relating counts of undamaged shoots to estimates of percent defoliation of current growth. The estimates are obtained from foliage samples taken for budworm egg mass surveys. - RM (136).

The number of eggs in western budworm egg masses laid on Douglas-fir and white fir can be rapidly estimated. The estimates are obtained from a conversion table which is based on number of eggs per mass and length of egg mass. - RM (137).

A new and comprehensive book discusses many of the potential uses of remote sensing and presents a technical appraisal of currently used sensors and discrimination techniques. This book considers aerial photography in the visible spectrum and sensing in all spectral regions where the atmosphere permits. - PSW (133).

A review of current remote sensing techniques and applications to all disciplines--agriculture, forestry, geography, geology, hydrology, and oceanography--has been published. This publication resulted from a one-week seminar organized in Paris from November 3-6, 1969, by the French Space Agency and the University of Michigan. - PSW (130).

Analysis of weeviled tree data collected from plots scattered from Maine to Virginia revealed that the 1/10 acre plot is the best size sampling unit for estimating white pine weevil injury in plantations. Tables have been developed for determining the number of sample plots for various size plantations at several densities, different precision levels for the proportion of never-weeviled trees, various clustering factors, and different cost ratios. - NE.

Data on balsam fir mortality obtained from stands following a spruce budworm outbreak in northwestern New Brunswick were analyzed using multiple regression screening techniques. The analysis revealed that average tree basal area, basal area per acre of balsam fir, percentage of stand basal area consisting of fir, and number of trees per acre of all species were expressive of relative hazard in a normal stand structure. Also reduction in stand hazard would result from effecting some degree of stand isolation. - NE.

Photographs taken from space as part of NASA's Apollo 9 SO-65 multiband photography experiment were evaluated for use in forest resource surveys. Infrared color film with a Wratten-15 filter was found to be the best film-filter combination for separating forest from other land uses. Interpretation of forest land on these small-scale photographs had to rely on color and texture. The minimum ground resolution that could be measured was 300 feet. - PSW.

In a study of tree damage following Douglas-fir tussock moth defoliation in California, large-scale 70-mm. color aerial photography was an effective sampling tool and took less time and expense than ground methods. Comparisons of results with a sample ground cover showed a high correlation for tree mortality and top kill. - PSW.

7. ROOT DISEASES

a. Annosus root rot

The thermal inactivation of conidia and basidiospores of Fomes annosus has been determined. The conditions resulting in inactivation of both conidia and basidiospores indicate that spores landing on stump surfaces during the summer in the southern United States would not likely survive and cause infection. Thus, thinning pine plantations during this relatively safe period may reduce losses due to F. annosus. - SE (167).

Freshly cut stump roots were successfully inoculated with as few as 44 conidia of Fomes annosus applied to a small root surface area. This confirms that spores filtering through the soil could initiate infection on

stump roots. Control measures directed at preventing stump infection through the cut surface are not 100 percent effective in preventing stump-root infection. - SE (153).

A reliable greenhouse technique of inoculating pine seedlings with Fomes annosus has been developed. Factors influencing the number of seedlings killed included the type of wound (open or slit), wounding versus nonwounding, and soil temperature. No variation in virulence of the eight isolates of the fungus was demonstrated. - SE (152).

The world literature on means of spread and pathways of infection of Fomes annosus has been reviewed. - SE (149).

Field inoculation of roots of 13-year-old slash, loblolly, and longleaf pines showed longleaf less susceptible to Fomes annosus than loblolly and slash pines. An inverse correlation of amount of resin exudation with degree of infection was found among the tree species. This is contrary to previous reports which suggested that accumulation of resin at sites of infection by F. annosus was a mechanism of resistance. - SE.

Studies on the rate of spread of Fomes annosus were conducted in California and the southern United States. The mean rate of spread appears to be influenced by such site factors as soil type. These studies will enable pathologists to predict losses in an area in a given time period. - PSW, SE.

b. Clitocybe root rot

Clitocybe tabescens has been associated with decline and death of Chinese elm and water oak. This is the first report of this fungus being isolated from Chinese elm. - SO (148).

Clitocybe tabescens was isolated from roots of dying sand pine at several locations in Georgia and Florida. Infection of sand pine (Ocala race) by C. tabescens in all plantations was related to hardwood debris left in the soil following site preparation. - SE.

c. Other root diseases

Western redcedar trees, released and thinned in 1940, had root rot and chlorosis 20 years later. Armillaria mellea was the most frequently isolated root pathogen, followed by Corticium galactinum, Poria weirii, and Fomes annosus. - INT (151).

Assaying soil for content of microorganisms that produce antibiotics against a specific fungus is usually laborious and time-consuming. Recently, however, researchers have developed a simple method of assaying soil for inhibitory fungi. The root pathogen, Poria weirii, is being used as the test organism. - PNW (155).

Many naturally occurring phenolics inhibit growth of Poria weirii, the root-rotting fungus that causes extensive mortality of western conifers.

The concentration of inhibitors is low in Douglas-fir and high in alder. These differences could account for resistance to P. weirii by plants such as Alnus rubra. - PNW (154).

d. Mycorrhizae

Ectomycorrhizae of pine are biological deterrents to pathogenic infection by zoospores of Phytophthora cinnamomi. Leucopaxillus cerealis, an ectotrophic mycorrhizal fungus, produced the antibiotic diatretyne nitrile which at 50 ppm. inhibited germination of zoospores of the fungus. - SE (156, 162, 163).

Bacteria in forest soil leachate influence the mode of infection of aseptically grown shortleaf and loblolly pine roots by Phytophthora cinnamomi. In the presence of soil bacteria, P. cinnamomi infection was only by means of zoospores. Thus, this plant pathogenic organism is stimulated by, or dependent on, associated soil organisms for the initiation or completion of certain physiological processes essential for pathogenicity. - SE (157).

Scleroderma bovista, a pecan symbiont, produced antibiotics effective against Pythium spp. which cause feeder root necrosis. Mycorrhizae formed by S. bovista apparently increased the absorbing capacity of the root system of pecan, and functioned as a biological deterrent to feeder root infections of pecan by the various Pythium species. - SE (158).

An air-filtered, air-conditioned, plant-growth room is described and results of initial studies on ectomycorrhizae of pine in the room are presented. Using this plant-growth room, natural forest conditions can be more closely duplicated for studies on ectomycorrhizal versus non-mycorrhizal relations. - SE (159).

Basidiospores of Thelephora terrestris introduced into root substrates of aseptic loblolly pine seedlings formed abundant ectomycorrhizae. This supports the contention that airborne basidiospores serve as primary agents of dissemination and inoculum for basidiomycetous ectomycorrhizae fungi. - SE (164).

Nineteen fungal symbionts were isolated from ectomycorrhizae of shortleaf pine seedlings grown in heavily fumigated soil in a greenhouse. Cultural and chemical characterization revealed five distinct cultural groups. One symbiont group was culturally identical with isolates of Thelephora terrestris. The other four groups belong to different species. - SE (161).

In a special plant-growth room, isolates of Thelephora terrestris produced basidiocarps and formed typical ectomycorrhizae with seedlings of Douglas-fir and 16 species of pine. Atypical mycorrhizae (no mantle) were formed on seedlings of Norway spruce and jack, Japanese red, and Himalayan pines. Pisolithus tinctorius formed typical mycorrhizae with several pine species. Both of these organisms are of potential value as introduced symbionts in reforestation and afforestation. - SE (160).

Pteridiospora spinosispora, sp. nov., an ascomycetous fungus, was shown to be a mycorrhizal symbiont with sweetgum and several other hardwood species. - SO (147).

The effect of water impoundment on mycorrhizae and soil microflora has been studied at the Southern Station. The number of fungi isolated from submerged sweetgum and red oak roots was not significantly different from those isolated from roots not subject to flooding. This information should be of particular value to foresters concerned with green tree reservoirs and to other researchers interested in effects of flooding on the forest. - SO.

Phytochemical studies of numerous mycorrhizal fungi reveal that all produce ergosterol. Since ectomycorrhizal fungi typically form a fungus mantle around root tips, ergosterol is probably important in erecting a physical barrier to pathogens. - PNW (145).

Mycorrhizal deficiency in a Douglas-fir region nursery resulted from such nursery practices as land leveling combined with stringent soil fumigation. Fumigation and other practices that reduce populations of soil organisms must be used with great caution. - PNW (175).

Two newly discovered ectotrophic mycorrhizae of Douglas-fir, each formed by a distinct strain of Poria terrestris, were described. The two strains of Poria terrestris are considered to be at least distinct varieties. - PNW (176).

Sporocarps of Endogone lactiflua were found associated with 2- to 3-year-old species of pine and Douglas-fir. The occurrence of this ectomycorrhizae-forming fungus appears to be limited by environmental factors (e.g., soil type) as yet undefined. - PNW (146).

An efficient method for isolation of the mycorrhizal fungus, Cenococcum grandiforme, from sclerotia has been developed. - PNW (174).

e. Nematodes

Lance, pine cystoid, and root-lesion nematodes parasitized most of nine southern pine species tested in the greenhouse. - SE (171).

Seedlings of slash, longleaf, and loblolly pines were severely stunted when grown in the greenhouse in soil infected with stubbyroot nematode, Trichodorus christiei. - SE (169).

In-row, preplanting fumigation with DD and DBCP in a longleaf pine plantation was evaluated for nematode control, improved seedling survival, and early and uniform release of seedlings from the grass stage. Seedlings in rows fumigated with DD started height growth earlier and produced taller trees after 5 years than those in nonfumigated rows. - SE (170).

Parasitism tests showed lance nematode parasitic on sycamore and cottonwood; spiral nematode parasitic on sweetgum, sycamore, cottonwood,

and yellow-poplar; dagger nematode parasitic on sycamore and yellow-poplar. Xiphinema chambersi was proved pathogenic on sweetgum. - SE (169).

Aphelenchoides cibolensis, n. sp., a mycophagous nematode, was found in ponderosa pine stands in New Mexico. In addition to feeding on many mycorrhizal fungi, it also feeds on fungi that cause root diseases of forest trees. The nematode failed to parasitize ponderosa pine seedlings grown in the greenhouse. - RM (166).

8. STEM DISEASES

a. Native rusts of conifers

The albino form of Peridermium harknessii was shown to have the capacity of monokaryotization in germinating aeciospores. This adds credence to the hypothesis that the albino gall rust spreads directly from pine to pine. Damage from this rust probably can be minimized by sanitation salvage cuttings that capture usable logs and reduce the hazard of new infections. - INT (183).

Chrysomyxa ledi var. glandulosi was found not to require spruce for self-perpetuation in the Uinta Mountains of Utah. Instead, it overwinters in Ledum glandulosum and intensifies by uredinial spread. - INT.

Basidiospores of Cronartium comandrae have little potential for redispersal if intercepted by plants and rocks during dissemination from comandra to lodgepole pine. Further studies of the effects of environment on basidiospores during dispersal may lead to improved silvicultural control of comandra blister rust through manipulation of vegetation, particularly on western rangelands. - INT.

Virginia pine has been planted as a substitute for comandra-susceptible loblolly pine on the Cumberland Plateau of eastern Tennessee. No natural comandra rust infections have been found in the field on Virginia pine, but potted Virginia pine seedlings did suffer approximately 25 percent infection. This does not indicate that Virginia pine can be attacked by comandra rust. - SE (204).

b. White pine blister rust

Procedures for growing tissue cultures derived from needles of Pinus monticola have been developed. Like stem cortex-derived cultures, needle-derived tissue cultures can be infected and provide suitable media for growing Cronartium ribicola. Although this rust fungus is grown on media devoid of living host tissue for short intervals, its sustained growth without physical contact with the host is possible only when the fungus is grown on membranes placed on media having imbedded host tissue cultures. - INT (184, 185, 186).

The significance of natural inactivation of lethal rust cankers, caused by Cronartium ribicola, in western white pine trees is being studied at the Intermountain Station in Moscow, Idaho. In 1965, 62 percent of the lethal white pine blister rust cankers sampled were inactive. Tuberculina maxima, which is thought to be the principal cause of the surveyed inactivation, was found fruiting on 24 percent of the active lethal-type cankers. - INT (194).

Progress toward securing high-level, long-lasting resistance to conifer rusts has been encouraging. Substantial gains have been made in critical definition of conifer rust epidemiology, and these gains are leading to routine success in securing uniform and heavy inoculations with conifer rusts. Identification of a few discrete resistance genes constitutes a good beginning toward unraveling the genetics of host resistance. - INT (181, 182).

Preformed inhibitory compounds in foliage of both resistant and susceptible Pinus monticola affected Cronartium ribicola basidiospore germination. Ether fractions from several resistant trees depressed basidiospore germination 40 to 95 percent. These compounds may have a role in preventing penetration and establishment of the rust. - INT (188).

Foliage dry-matter content was measured to determine its association with western white pines that are resistant and susceptible to blister rust. No significant difference between blister rust resistant and susceptible trees was found. - INT (209).

Considerable variability occurs in the characteristics of blister rust cankers on eastern white pine. Three distinct canker types were identified on the basis of physical appearance, growth rate, and sporulation. Lack of knowledge concerning variability in canker characteristics undoubtedly contributed to misinterpretation of results obtained in early tests on the use of antibiotics to control this disease. - NC (202).

Several growth-regulating compounds, organic chemicals, and conventional fungicides were not effective in eliminating blister rust cankers in eastern white pine. - NC (203).

c. Fusiform rust

The best hope for the control of fusiform rust seems to lie in growing resistant pines rather than in direct chemical controls. Whether these resistant pines are simply species other than loblolly and slash pine, selections within species, or new hybrids, will depend upon the results of present research programs, and the eventual choices that foresters make, based upon individual needs for a particular site and area. - SE (203).

Investigations are in progress at the Southern and Southeastern Forest Experiment Stations to determine if pathogenic variability exists in Cronartium fusiforme. While the results of initial studies do not indicate pathogenic races of the fusiform rust fungus, they do show differences in levels of pathogenicity. This fact has important implication to workers in programs of breeding rust-resistant pines. - SE, SO (216).

In a recent study, the volume-size distribution of aeciospores of Cronartium fusiforme and C. quercuum was determined by using a Coulter Particle Counter. The mean aeciospore volume (MAV) for C. fusiforme was significantly less than that for C. quercuum. The MAV for C. fusiforme also varied between host sources. This is the first report of spore size differences between these two closely related pine-oak rust fungi. - SE.

Pathogenic races of Cronartium quercuum have been found at the Southeastern Station. The existence of physiologic races makes it necessary for tree breeders to consider the possibility of new and different strains of rust developing which may attack improved pine selections. - SE.

The albino strain of Cronartium fusiforme appears to be a valuable marker for genetic studies of this fungus. White aeciospores were discovered on plants which were originally inoculated with an orange isolate of C. fusiforme and grown adjacent to pines infected with the white strain. This suggests that cross-fertilization occurred and is the first evidence that the pycnial stage is functional. - SO (216).

In a study of the epidemiology of Cronartium fusiforme, basidiospores were collected in sporetraps operated at different heights above ground level and at varying distances from oak trees. The greatest concentrations of spores occurred near the ground and under oak trees. Spore numbers decreased rapidly with height above ground level and with distance from oaks. Vegetative barriers to screen these spores from night breezes in which they are dispersed and removal of oaks in and near pines appear to be good possibilities for field control of fusiform rust. - SO (216).

d. Scleroderris canker

On National Forest land in Upper Michigan and northern Wisconsin, 66 percent of the red pine plantations and 88 percent of the jack pine plantations are infected with Scleroderris lagerbergii. In infected stands it is the main cause of mortality, and a substantial area of plantation has been destroyed by this disease. - NC (215).

The relation between temperature, rainfall, and the discharge of ascospores of Scleroderris lagerbergii have been studied. The results provide a more effective basis for timing fungicides to control the disease. - NC (213).

The Scleroderris canker fungus has been found in northern Minnesota in two locations on the Superior National Forest. The potential of the disease for spread and intensification on the Superior National Forest is unknown. - NC (214).

The difficulty of observing the transparent germ tubes of Scleroderris lagerbergii spores precluded study of the infection process. A method has been developed for labeling the spores with a fluorescent brightener

without inhibiting germination. Using this technique, penetration of host tissue by the fungus can be observed. - NC (214).

Preliminary results from tests at the North Central Station of several fungicides for control of the Scleroderris canker fungus indicate that Maneb is effective if applied at high concentrations. - NC.

e. Aspen cankers

Hypoxylon canker is a serious disease of aspen in the Lake States and in parts of Colorado, but its distribution in the Southwest has been poorly known. This disease is now known to extend to the southern limits of aspen in the Southwest. - RM (205).

Examination of Nectria-like aspen cankers at various localities in Minnesota in 1969 revealed the presence of four species of Ceratocystis not previously reported for the State. Cenangium singulare, another damaging, canker-causing parasite of aspen in Colorado, was also found in aspen stands in Minnesota where it appeared to be saprophytic on dead aspen bark. - RM, NC.

One new genus and three new species of nematodes were recovered from necrotic tissues of Cenangium and Ceratocystis cankers of aspen. All nematodes appeared to be associates or parasites of insects and were probably carried to the diseased trees by various species of nitidulids. - RM (197).

Tissue cultures of quaking aspen have been used to study the physiology of infection by the Hypoxylon canker fungus. Tests have shown that the fungus will grow on this material and that it can penetrate some distance beneath the surface. Further research is underway to learn more about the establishment of a host-pathogen relationship. - NC.

f. Other canker diseases

Poria obliqua and Polyporus glomeratus cause rot and cankers in trees. The cambium is killed as the pressure exerted by the advancing margin of the sterile conks increases, with the result that a canker is formed. - NE (210).

A basal stem canker of sugar maple is common on trees in the Lake States. The cankers are usually elongate, usually encompass about one-fourth of the stem circumference, and face the south. Many of the cankers have failed to heal although more than 30 years old. - NC (193).

g. Dwarf mistletoes

There is a paucity of critical information on the upward spread of dwarf mistletoes through tree crowns. Average upward spread in inoculated Digger pines was found to be nearly 2 feet per year. This rapid rate of intensification is not necessarily indicative of the behavior of other species of dwarf mistletoes. - RM (187).

A monographic study of the taxonomy, hosts, and distribution of the dwarf mistletoes of the world was completed. The manuscript will be issued as a USDA Agricultural Handbook. - RM.

Temperature has been found to influence penetration and infection of Digger pine and Monterey pine by dwarf mistletoe. No penetration or infection occurred at constant temperatures of 27° C. or above. - PSW (206).

Height and age of understory red fir were related to dwarf mistletoe infection from the surrounding overstory red fir on four National Forests in California. Percentage of trees infected and intensity of infection increased significantly as height of understory tree increased. Several approaches for silvicultural control are presented on the basis of this study. - PSW (208).

Cytospora abietis was commonly found associated with dwarf mistletoe parasitizing branches of white fir and red fir. Geographic location in California and age of dwarf mistletoe were not important factors influencing infection by C. abietis. - PSW (207).

Dwarf mistletoe (Arceuthobium douglasii) does not occur in Douglas-fir stands of western Oregon and Washington and central Montana. Inoculation experiments have demonstrated Douglas-fir from these areas is susceptible to infection by this dwarf mistletoe. Other factors likely account for this parasite's current distribution. - INT (217).

The effect of temperature and relative humidity on longevity of stored dwarf mistletoe seeds has been studied. Storage of seed from ponderosa pine dwarf mistletoe at 1° C. and 1, 7, and 9 percent relative humidity gave acceptable germination (97 percent) after 5 months. The ability to retain seed viability for prolonged periods greatly increases opportunities for study of host-parasite relations and potential control measures. - PNW (195).

Invasion of ponderosa pine bole wood by dwarf mistletoe changes wood properties significantly. These changes adversely affect wood quality as well as reduce tree growth. - PNW (196).

(For an additional item relating to IIB 8 see paragraph under IB 2.)

h. Discoloration and decay

A photo guide has been prepared to assist in estimating the extent and severity of discoloration and decay in northern hardwood trees. - NE (212).

Some 22 different species of fungi were found associated with decay in upland oak stands of Kentucky. Fire scars were the most important means of entry of the decay fungi. A rotation of not more than 90 years is suggested for upland oak stands in Kentucky. - NE (179).

Twelve different species of heart rot fungi were isolated from decay columns in northern red oak. Two species, Poria cocos and P. oleraceae,

accounted for about 25 percent of the total decay volume. From the decay standpoint, northern red oak should be an excellent tree to manage for lumber production. - NE.

A study of sound and decaying red oak showed that the oxygen concentrations in the stem were less than 2 percent in sound trees but nearly 4 percent in decayed trees. Carbon dioxide concentrations varied between 14 and 20 percent in sound trees and between 7 and 21 percent in decayed trees. These observations suggest that oxygen and carbon dioxide concentrations in the host influence the activities of wood-decaying fungi and may also suggest why decay columns often become inactive after the infection court has healed. - NE (189).

Temperature fluctuations of plus and minus 3° C. and 6° C. around a temperature mean of 21° C. increased growth of four wood-decaying fungi, while a fluctuation of plus and minus 11° C. decreased their growth. Comparison of these data and tree temperature data suggested that growth of wood-decaying fungi in trees may also be influenced by fluctuations in tree temperatures. - NE (190).

In Mississippi, sporophore production of Polyporus hispidus occurred from July to October. Maximum size was attained in approximately 10 days. Variations in spore production did not appear to be correlated with changes in temperature or relative humidity. These results lead to better understanding of the life cycle of rot fungi. - SO (198).

Two patterns of daily basidiospore production were defined on six wood-rot fungi in 1968-69 near Stoneville, Mississippi. One group fruited in the summer; the other group in the fall and winter. - SO.

9. SYSTEMIC DISEASES

A technique has been developed for inoculating plants with vascular pathogens such as oak wilt. It uses serum vial stoppers as a reservoirs for the inoculum suspension and a relatively nontoxic and fast-acting adhesive to attach them to the host. - NE (218).

The oak wilt pathogen grown on two synthetic media produced a toxin that caused a wilting syndrome similar to that of oak wilt on oak seedlings. The data suggest the toxin to be a polysaccharide. - NE.

10. FOLIAGE DISEASES

a. Air pollution

Changes in amounts of total soluble carbohydrates and ascorbic acid were related to needle length of eastern white pine. It is suggested that the relatively low carbohydrate content may have been indicative of a slow maturation of needle tissues, which may be related to a prolonged sensitivity to air pollutants. - SE (219).

Research at the Southeastern Station indicates that certain eastern white pine trees are extremely sensitive to low levels of sulfur dioxide. On the trees tested, sulfur dioxide was considerably more phytotoxic than ozone.--SE (220).

A study on the effects of air pollution on fertilized potted ramets of eastern white pine clones found that fertilization reduced the extent of necrosis of needle tips in several sensitive clones. In the field experiment, other symptoms, such as banding and mottling, were not alleviated by fertilizer application.--SE (220).

In the first phase of bioindicator work, just completed, 1,439 eastern white pine seedlings were screened in the field. Some 435 exhibited specific sensitivities to three different air pollution regimes which were predominantly either sulfur dioxide, fluorides, or oxidants. Sixty-four seedlings were resistant to all air pollution regimes.--SE (220).

An aerial survey of the San Bernardino National Forest showed that 1.3 million ponderosa pine trees in an area encompassing 160,000 acres are being killed or injured by air pollution.--PSW (227).

A study on the response of ponderosa pine seedlings to ozone indicates that photosynthesis rate was a sensitive index for ozone dosage response. Premature needle abscission probably results from carbohydrate depletion.--PSW (228).

Photochemical oxidant damage was observed on 16 native conifer species in California during a 3-year period. The most serious damage was to ponderosa pine, Jeffrey pine, Coulter pine, Monterey pine, and bigcone spruce. Knobcone pine was slightly affected. No injury was observed on Digger pine, singleleaf Pinyon pine, western juniper, giant sequoia, or redwood.--PSW (228).

Ambient levels of ozone and sulfur dioxide, independently and in combination, promote early symptoms of premature defoliation and needle mottle on susceptible eastern white pine ramets. Possible synergistic interactions between these gases may explain the occurrence of chlorotic dwarf in plantations where atmospheric levels of either gas alone are too low to cause typical damage.--NE (221).

b. Chloride toxicity

A previously unexplained tipburn of ponderosa pine in a Denver, Colorado, area has been related to high sodium and chloride accumulation in the needles. Typical symptoms of tipburn were produced in healthy pines by addition of high concentrations of chloride, but not of sodium, to their water supply. The important sources of chloride in nature appear to be saline water from wells, lakes, or natural seeps.--RM (233).

c. Pine needle diseases

Since publication of the name Lophodermium ponderosae in 1964, the genera of the family Hypodermataceae have been revised by Darker. Recent studies on this needle cast indicate that the fungus should now be known as Davisomycella ponderosae.--RM (223).

Dothistroma pini was found causing damage to 8- to 10-year-old Monterey pines in Uruguay; this fungus had not previously been reported from Uruguay.--RM (230).

Dothistroma pini needle blight is damaging to Austrian and ponderosa pines in shelterbelts and other plantings in the central and southern Great Plains. During investigations to determine the time of infection, plastic leaf prints were made of surfaces of needles collected after rains that resulted in dissemination of conidia. The direction of growth of the germ tubes was toward stomata on resistant needles as well as on needles susceptible to D. pini infection.--RM (230).

A new needle disease of ponderosa pine plantations has reached damaging proportions in western Oregon. Disease symptoms have been defined and climatic factors necessary for spore discharge, infection, and disease development have been delimited. Epidemiological studies along with surveys and control efforts are continuing.--PNW (232).

The brown spot disease, caused by Scirrhia acicola, is a new problem in Wisconsin where it had reached epidemic levels in several Scotch pine Christmas tree plantations. The disease defoliates the infected trees, making them unsalable. It has already been recognized that Scotch pine varieties vary considerably in susceptibility, with the favored short-needled varieties being most susceptible.--NC (229).

Since 1966, many millions of red and Scotch pines have died or been severely defoliated by a needle cast disease caused by Lophodermium pinastri. Evaluation of the fungicide Maneb showed that if several sprays are applied during the growing season they are effective in controlling the disease.--NC (223).

d. Other foliage diseases

A new species of Phyllachora causing a tarspot-like disease on Persea borbonia was described and given the name Phyllachora perseae.--SE (225).

11. VIRUS DISEASES

Scion material obtained from elm phloem necrosis-infected trees and from trees infected with walnut bunch disease was successfully patch-grafted to American elm and black walnut, respectively, in nursery-grown trees. Preliminary electron microscope examinations of elm root and

stem phloem tissues show the presence of mycoplasmalike bodies in phloem necrosis-infected scion material. More detailed electron microscope studies are being initiated.--NE.

12. DETERIORATION OF WOOD

Southern pine wood can be deteriorated by stain, mold, and decay-fungi from the time a tree is felled until the wood is thoroughly dried or preservatively treated. Current research trends should provide improved methods of protecting most green or seasoning products and most products in use.--SO (238).

Shipping boxes and crates are commonly made of woods with low natural resistance to fungi and insects. Several 3-minute dip treatments in various wood preservatives have been shown to protect wood boxes stored off the ground for more than 10 years in both a southern and a northern climate.--SO (239).

A laboratory preparation of "green liquor," an intermediary formed during the recovery of chemicals from pulpwood digestion process, showed great promise for use as a means of controlling microbial degradation of stored pulpwood chips. Estimated potential savings resulting from the successful control of chip degradation during storage could exceed $2 million per year.--FPL (237).

13. BIOLOGY AND TAXONOMY OF FOREST FUNGI

Continuing studies on Pythium species demonstrated the heterothallic nature of P. catenulatum and P. splendens. Soil isolation studies under different forest and crop plants added to the collections of Pythium species for taxonomic studies and host relationships.--SE (242, 243, 244).

Isolation of organisms associated with Fomes annosus and other wood-rotting fungi in loblolly and slash pine root bark and wood resulted in the recovery of 30 species of Mucorales. The significance of these organisms in the decomposition of roots and bark and their relationship to survival of F. annosus are not known at present.--SE (245).

At the Beltsville Forest Disease Laboratory, 78 fungal cultures were received for identification during the year. In addition, 156 isolates of fungi were shipped to various requesting agencies, and 510 cultures, including 25 species new to the collections, were added to the Reference Culture Collections. The culture collections now number 11,676 isolates (representing 1,189 named species).--WO (249).

14. MISCELLANEOUS STUDIES

Cankers, stem dieback, and various leaf normalities were found on yellow birch seedlings surveyed for disease symptoms. Valsa ambiens was frequently isolated.--NC (255).

An electric psychrometer for remote sensing and recording of relative humidity has been developed by the Southern Station. A computer program is also available for reducing the raw data.--SO (252).

Douglas-fir bark is added to the forest floor in large quantities as sloughing from standing and fallen trees and from logging debris. Concern about possible adverse effects of tannins in bark on soil chemical or biological properties has been allayed by recent research. The bark and its tannins were found to produce no harmful effects.--PNW (251).

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C. Accelerating Forest Resource Surveys

1. FOREST INVENTORY

Approximately 46 million acres of commercial forest land were inventoried during the past year. Field surveys were conducted in Alaska, Arkansas, California, Florida, Maine, Oregon, and Wisconsin. Publications appraising the forest situation were issued for 12 States or parts of States.

The time between resurveys of States now averages about 11 years. The forestry situation is changing rapidly in most States because of shifts in land use and industrial expansion that has resulted in large increases in timber removals. Such changes put increasing emphasis on the need to accelerate and intensify the Survey to provide up-to-date and detailed data for guiding forestry and rural development policies and programs.--WO.

Forests continue to be the dominant land use in Mississippi with commercial forests (16.9 million acres) covering 56 percent of the State's land area. Between 1957 and 1967 the softwood growing stock volume increased 63 percent to 6.6 billion cubic feet. The hardwood growing stock remained stable at 6.5 billion cubic feet. In 1966 growth was 335 million cubic feet and removals 287 million cubic feet.--SO (9, 22).

In 1967 Indiana's growing stock volume was 3.5 billion cubic feet, a 25 percent increase in the 17 years between surveys. Oaks, hickory, and hard maple made up 98% of the volume. The commercial forest land area was 3.9 million acres, slightly below the area reported in the earlier survey. Removals in 1966 totaled 64.9 million cubic feet, about two-thirds of the net growth for that year.--NC (15).

A fourth Forest Survey in South Carolina shows that the area of commercial forest land increased from 11.9 to 12.4 million acres between 1958 and 1968. This is a result of an extensive tree planting effort and the natural reversion of idle agricultural lands to forest. Volume of growing stock increased from 10.3 to 12.2 billion cubic feet, or 19 percent. In 1967, net growth of growing stock exceeded removals by over 200 million cubic feet, or 48 percent.--SE (13).

The 3.1 million acres of commercial forest land in five counties of the Olympia Peninsula contain 15.3 billion cubic feet of growing stock and 81.5 billion board feet of sawtimber, about one-third of the total commercial forest land and timber volume in western Washington. Western hemlock type occupies 39 percent and Douglas-fir type 29 percent of the commercial forest land. Three-fourths of the commercial forest land was in stands under 100 years of age. The net annual growth of sawtimber in 1965 was 1,610 million board feet and removals 1,540 million board feet.--PNW (3).

Hurricane Camille, which struck the Gulf Coast on August 17, 1969, damaged 290 million cubic feet of timber in 15 counties in southern Mississippi. Included in this estimate are some 1.2 billion board feet of sawtimber, of which nearly three-fourths was pine. Loss in pines was largely due to breakage but blowdown was the major form of hardwood damage.--SO (6, 17, 18, 21).

The 4.2 million acres of commercial forest land in 7 counties in Michigan's eastern upper peninsula supported 3.3 billion cubic feet of growing stock in 1966 and 7.7 billion board feet of sawtimber, up 29 and 33 percent respectively from 1955. Hard maple, the most prevalent species, increased 58 percent.--NC (4).

In 1967 the 28-county Ohio hill country region contained 4.4 million acres of commercial forest land, about 70 percent of the State's total. The commercial area was 33 percent above that in 1952. Volume of growing stock increased at about the same rate to 2.9 billion cubic feet and sawtimber to 9.8 billion board feet. Average net annual growth of growing stock exceeded 100 million cubic feet and sawtimber 350 million board feet. Timber removals were about 40 percent of the net annual growth.--NE (5).

2. TIMBER PRODUCTION

Recent Forest Surveys show substantial gains in softwood inventories in the South. These increases occurred largely in diameters suitable for poles. Despite the large timber supply and favorable prices, only 2 percent of the South's softwood harvest in 1966 went to poles. The West and Intermountain regions also have a large supply of trees suitable for poles.--SO (37).

Southern pulpwood production increased 10 percent in 1968 to a new high of 37,075,355 cords. Gains were made in output of both roundwood and residues. Expansion of existing mills and construction of 7 new mills boosted daily pulping capacity to 77,140 tons. One hundred southern pulpmills were operating, and 4 more were under construction at the end of 1968.--SO (24).

Total wood supply in the Columbia-North Pacific region is projected to decline 11 percent by 2020. This decline is expected to take place primarily in those areas which have traditionally been the major centers of forest industry--western Oregon, western Washington, western Montana, and northern Idaho--in response to a drop in log production from private lands. Total employment in the forest industries in Columbia in 2020 is expected to be about two-thirds of the 1965 level. Despite the decrease in total employment, increasing productivity is expected to result in a twofold increase in payrolls by 2020.--PNW (39).

Total veneer log production in the North in 1968 was 243.7 million board feet, up 1.6 percent from 1963. However, in the Central and Lake States regions production was down 8.8 and 9.3 percent respectively, while in the New England and Middle Atlantic regions production was up 1.8 and 21.3 percent respectively. Birch represented 28 percent of the total harvest.--NE (31).

In 1962, 130.2 million cubic feet of sugar maple growing stock was cut in the United States, including 505 million board feet of sawtimber. Half of the sugar maple harvest in the United States occurs in the North Central Region. - NC (29).

The pulp industry paid more than one-quarter of a billion dollars for Midsouth pulpwood in 1968. Roundwood averaged $17.75 per cord for pine and $15.86 for hardwoods. Chipped residues were $6.86 per ton for softwoods and $6.09 for hardwoods.--SO (25).

Mills in the Southeast paid record prices for pulpwood in 1968; however, price increases were below the previous 4-year average. Prices paid in 1968 average $19.85 per cord for pine bolts, $15.60 per cord for hardwood bolts, $8.10 per ton for pine chips, and $6.30 per ton for hardwood chips.--SE (35).

Industrial roundwood harvest in New York in 1967 amounted to nearly 100 million cubic feet, an increase of 7 percent over 1950. Although the number of operating sawmills decreased from 1,557 in 1952 to 302 in 1967,

sawlog production dropped only 27 percent, from 484 million board feet to 353 million board feet. Saw logs made up 57 percent of the total roundwood production. About 80 percent of this saw-log production was from the hardwood species.--NE (34).

Pulpwood production in the Lake States dropped to about 3.5 million cords in 1968, 413,000 cords less than in 1967 and the lowest recorded since 1962. Around half of the decline in roundwood harvest occurred in aspen, the major pulpwood species in the Lake States. Production in the Central States of 330,000 cords was the highest ever reported.--NC (26, 27, 28).

The industrial roundwood harvest in Ohio in 1966 of 96 million cubic feet was more than double that of 1951. Saw-log production increased 83 percent to 390 million board feet in 1966, and made up 62 percent of the total roundwood production. Pulpwood production of 27 million cubic feet accounted for 28 percent of the total.--NE (32).

Pulpwood production in the Northeast was slightly below 6 million cords in 1968 and about 1 percent under the record high in 1967. Round pulpwood production decreased by more than 5 percent but the wood chip production of 941,000 cords was 32 percent above 1967. Daily pulpwood capacity increased 5.3 percent per year during the 1965-68 period. At the end of 1968, 8 new mill or mill-expansion projects were under way in the Northeast area.--NE (33, 38).

3. SURVEY TECHNIQUES

Five years of field tests have proved that the mirror caliper--a hand-held, nonmagnifying, optical caliper--is a practical instrument for use in taking upper-stem measurements (diameter outside bark) at any point on a standing tree. Parallel lines-of-sight produce direct-reading measurements within a range of 3.5 to 16.0 inches. Accurate readings can be taken in approximately 30 seconds.--SE (43, 44).

(For additional items relating to IIC 1 see paragraphs under III A 7; to II C 3, see under II I.)

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analysis are used in the model. As with other multiple-use models, the technique developed for the Salt-Verde basin in Arizona considers all feasible treatments, costs, and product yields simultaneously. The dynamic approach evaluates benefits and costs through time.--RM (10).

Evaluation of the effects of even-aged timber management on wildlife habitat reveals substantially different impacts on various wildlife types. Even-aged management places severe limitations on grey squirrel habitat; it is compatible with wild turkey management when large timber products are grown; and it is compatible with white-tailed deer habitat only when small-sized timber products are grown under intensive practices.--NE (13).

3. MEASURING MANAGEMENT COSTS AND BENEFITS

Costs of practicing forestry in the South in the period 1952-67 have increased from 200 to 700 percent. The increases were much greater than inflation in the general economy and the rise in forest products prices. The study analyzed costs of 11 major practices: controlled burning, seed bed preparation by bulldozing or disking, planting open land by hand and by machine, planting cutover land by hand and by machine, cutting to release young growth, poisoning undesirable trees, girdling undesirable trees, cruising, and marking trees for harvest.--SO (22).

Hardwood log values determined by the quality-index method are reliable estimates of product values for Forest Service high-quality, factory-grade logs. The quality-index method bases values on relative grade recovery when logs are sawn into 1-inch lumber. For logs of lower grades, the quality-index method tends to underestimate the log product values and value adjustments are necessary. Methods have been developed to adjust quality-index values to reflect local and regional price differences.--NE (18).

A recently developed system to inventory timber quality recognizes and measures basic stem characteristics and defect features that influence quantity and quality for most primary products. Stem defects measured included form defects, scar defects, and knot or limb characteristics. Timber inventory data obtained are used in conjunction with standard methods of volume estimation, scaling, and grading to estimate (1) gross volume, (2) probable volume reduction due to visual scaling defects, and (3) quality of timber in existing grading or quality classification systems.--RM (16).

(For an additional item relating to IID 3 see paragraph under IIIA 8.)

4. STIMULATING IMPROVED FOREST MANAGEMENT

Actual timber harvesting in 1960-67 differed sharply from intentions stated in 1960 by owners of nearly 200 forested properties in Michigan's

Upper Peninsula. Relatively high rates of timber cutting and forest management activities were directly related to forest acreage and merchantable volume whether or not owners had timber harvesting objectives initially. Owners intentions seem to vary cyclically. The cycle begins with growth accumulation that results in the value of merchantable timber becoming financially significant. After timber sales, owners again seem indifferent to timber growing. Other reasons for ownership claim the owners intentions until growth again creates significant value.--WO (25).

Of the 43 million acres in large private ownerships in the South, 58 percent are held or leased by the pulp industry, 26 percent by other forest industries, and 16 percent is in tree farms. Some 20 million of 30 million acres of pine sites are committed to rotations of 30 years or less. Successful pine plantations occupy 5 million acres. Many firms have started seed orchards from grafted cuttings from plus trees; drainage, bedding, and fertilization of timberland are gaining acceptance. In the next 10 years, 3.6 million acres of pine-hardwood and upland-hardwood stands will be converted to pine. Hardwoods, chiefly cottonwood, have been or are scheduled for planting on 200,000 acres.--SO (23).

5. IMPACTS ON FOREST INDUSTRY AND REGIONAL ECONOMIES

By 1975, the South may produce one-third of U.S. plywood, according to a linear programing analysis that estimated the production potential for the section. Effects of competition by the lumber industry, stumpage, relative costs of logging and manufacturing plywood and lumber in major forest regions, and costs of transport to the nation's markets were considered. Impediments to industrial migrations are apt to prevent the South from achieving a theoretical 56 percent of the Nation's output of plywood.--SO (26, 27).

Output of lumber and net revenue at sawmills is substantially increased by the addition of chipping headrigs that produces lumber and pulp chips simultaneously. Data collected indicate the operation of chipping headrigs requires little manpower. Output and net revenue of a large standard mill was compared before and after installing chipping headrigs.--SO (29).

Input-output analysis of the southern forest economy shows that primary processing industries produced $5.1 billion worth of output, while stumpage purchased cost $0.3 billion. Secondary processing industries converted a portion of this output to $3.4 billion of products. Collectively, forest related industries paid $2.2 billion in wages to southerners. The study used data from regional tabulations of the 1963 Census of Manufacturers unavailable to the public.--SO (28).

In the Douglas-fir region, total employment and population is expected to increase by 1980. Some areas, particularly southwestern Oregon, may experience population loss unless nontimber-producing employment increases substantially. Though the timber industry stimulates economic development of the Douglas-fir region, projections show that growth of economic subareas cannot be assured by a sustained level of cut from forests.--PNW (30).

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E. Improving Engineering Systems

Five engineering papers are available to assist manufacturers, forest managers, and logging operators to plan, design, and determine payload capability of skylines. The use of computers to handle the mathematics required in the design of skylines can reduce design workload by at least 5 times and thus can reduce design costs by more than half.--PNW (1, 2, 3, 4, 6).

A patent application for a simple 2-line slack-pulling carriage is being prepared. This is a very important invention because yarding of partial cuts over extended distances appears possible.--PNW.

Under several operating conditions transport of wood chips from the forest to mill in hydraulic pipelines is more economical than the transportation of wood by conventional methods. The major technical problems have been solved and the equipment and methods are being refined. The design, installation, and test of a pilot line is now possible.--INT.

Control of erosion is a critical consideration when steep unprotected slopes are necessary as highway embankments or other necessary earth structures in watersheds and commercial forests. Past research of erosion phenomena has dealt primarily with flat or nearly flat agricultural land. Laboratory data now available on the erosion phenomena will be field tested for validity to provide design criteria to control erosion from steep unprotected slopes.--INT (8).

Refinements in production methods and cost control in a progressive business are highly dependent on time and motion studies. Logging as part of the wood products industry must compete at the marketplace with rival products. Thus it is important that modern production control techniques be extended to use in the forest. Work sampling has been shown to be an accurate and economical method for logmaking time and motion studies.--INT (7).

A method for removing bark from wood chips would allow recovery of 10 to 30 percent more wood fiber per acre depending on species and type of harvest. Several methods (mechanical and liquid-medium processing) for removing bark from wood chips are under study. Preliminary results indicate that systems employing combinations of mechanical and liquid or chemical treatments could remove an acceptable amount of bark from wood chips. Extensive studies are in progress.--NC (10, 11, 12).

Equipment manufacturers and experimental engineers working in timber-based industries as those in other industries must evaluate equipment, processes, or production. Effective and economical evaluation of the operating characteristics of logging, handling, or processing equipment will result in more reliable machines and methods for the industry. Examples and design specifications for instrumentation useful in logging and processing studies are available.--NC (9).

Stability of logging vehicles, particularly machines such as articulated rubber-tired skidders operating on steep slopes, is a critical safety consideration. A technique has been developed to quickly predict the effect that slope, steering and orientation-to-slope angles, tire roll over, and tire torque have on static tipping. The technique developed can be used by equipment designers to design safer equipment, and safe operating conditions can be determined for existing market equipment.--NE

Tests in mechanizing the harvest of pine gum indicate that production can be increased by 12 times. Powered handtools, disposable containers, gum flow stimulants, and low-cost transport and collecting vehicles are the key. Mechanization is also important because it can upgrade the wage level of the worker, reduce fatigue, and attract woods labor.--SO (17, 23).

Large areas of cutover land and low-producing timber stands in the South must be regenerated. In addition, regeneration must follow current harvest to insure adequate timber supplies for the future. Tree shakers can remove more pine seed cones in 1 hour than a skilled climber can remove in a 7-week period. This is important since it takes greater advantage of the 2-week period between cone maturity and natural seed cast.--SO (16).

(For an additional item relating to II E see paragraph under III A 8.)

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F. Improving Water Quality and Yield

1. IMPROVING WATER YIELDS

A study of land use activities and hydrologic performance over a 43-year period (1922-65) in the 295-square-mile Ochoco Creek basin in central Oregon showed a significant increase in streamflow from about

1942 following increased timber harvest activity in the basin. Ochoco Creek helps feed Ochoco Reservoir, which irrigates more than 3,400 acres.--PNW (10).

A simple, inexpensive, accurate, snowmelt lysimeter-type gage has been developed in northern Idaho to provide continuous readings of water volume flowing from the base of a snowpack. Measure water comes from snowmelt or a combination of melt and percolated rain. Data obtained are applicable in river flood forecasting and in snow hydrology studies.--INT (26).

In contrast to a widely held belief, frozen soil zones do not necessarily impede soil water movement, according to field tests conducted on both sandy and silty soils over four winters in southwestern Wisconsin. A neutron meter, used to accurately log water movement into and through soils, produced one series of data showing water infiltrating and percolating through more than 60 cm. of hard-frozen ground. The percolate caused an increase of water in the frozen zone during spring melt.--NC (52).

Tree species that are more economical water users close their stomates quickly in response to stress caused by water deficiencies. Transpiration-decline curves obtained with excised twigs from 3-year-old seedlings at Wenatchee, Washington, indicated that stomatal closure occurs more rapidly in pines and spruce than in firs. Grand fir, Douglas-fir, ponderosa pine, lodgepole pine, and Engelmann spruce seedlings were used. In grand fir and Douglas-fir, a decline in transpiration rate in response to drought was associated with a relatively small reduction in size of stomatal aperture as compared with pines and spruce. The stomata of the pines and spruce are relatively sensitive to leaf moisture, whereas those of Douglas-fir and particularly grand fir are less sensitive.--PNW (39).

The amount of evapotranspiration by grass cover on a deforested 22-acre catchment in the southern Appalachians was closely related to the amount of grass produced. The catchment was cleared of hardwoods in 1958 and 1959 and Kentucky 31 fescue seed with fertilizer was applied in 1959 and 1960. During the first year after this treatment, water yield was about equal to the expected yield from the original forest. However, in subsequent years as grass production declined, water yield gradually increased until it exceeded the predicted yield from the forest by over 5 inches annually.--RM (29).

Two stream gaging stations of new design for measuring the discharge of large mountain streams were tested on the Beaver Creek pilot watershed in Arizona. Each gage provided a stable stage discharge relation with sufficient precision for long-term hydrologic investigations. The control surface is a 15-foot-wide concrete slab with a 6-inch triangular lip built into the downstream edge. Flow is metered on the concrete surface near the upstream edge of the slab. Capacity of the gage is in excess of 1,000 cubic feet per second.--RM (13).

Bogs in northern Minnesota were effective storage areas for short-term runoff but were ineffective as long-term storage areas or streamflow regulators. A 5-year study period of measured runoff from four forested bog watersheds showed that spring runoff, from the beginning of flow in late March to the first of June, accounted for 66 percent of total annual water yield. Summer and fall runoff was normally very low, and ceased in summer on most of the bogs.--NC (5).

Dragging a heavy chain over the ground plus windrowing in the pinyon-juniper vegetation type at a site in southwestern Utah significantly increased the permeability of surface soil samples at the 0-2 and 2-4 inch depths. Mechanical soil disturbance associated with chaining and windrowing probably increased soil aeration porosity through decreased bulk densities and incorporation of litter into the soil surface.--INT (23).

Clearing a 39-acre hardwood forest watershed located in the White Mountains of New Hampshire advanced cumulative streamflow an average of 4 to 8 days during periods of major snowmelt, but total streamflow volume for the entire snowbelt season was not significantly changed. Peak flows and high-flow volumes increased in the early part of the snowmelt season and decreased in the latter part as a result of earlier and more rapid snowmelt. Combined flow from the cleared area with an adjacent forested area suggests that clearing up to 25 percent of a hardwood forested area would not greatly affect the volume of downstream flows during the snowmelt season.--NE (30).

Streamflow increases ranged from 4 to 8 inches annually on two watersheds in the Fernow Experimental Forest, West Virginia, following a clearing of the lower half of one and the upper half of the other in 1964. Both cleared areas were kept barren after cutting. Water yield increase had no apparent relation to position of cleared area. Duration of small late summer flows (less than 1 cubic feet per square mile) increased greatly following clearing, but higher flow duration appeared unaffected by watershed treatment. Midsummer stream temperatures increased by 7° F. on the watershed with the lower half cut, but were unaffected on the watershed with the upper half cut. Between 1964 and 1967, streamflow turbidity and dissolved mineral content roughly tripled at all flow levels.--NE (45).

Water moving downslope below the soil surface, not over the soil surface, is the major source of high streamflows originating from wetted, unfrozen forest soils of the Allegheny-Cumberland Plateau region. Small plot and watershed studies showed greatest storm discharge from fine-textured soils and lesser amounts from coarse-textured soils. Concentrated subsurface stormflow occurred primarily from water passing through large openings in the soil profile made by burrowing animals and decayed roots.--NE (66).

2. MANAGING, REHABILITATING, AND IMPROVING WATERSHEDS

Prescribed burning increased stormflows, overland flows, peak discharges, and sediment production on a very small, grass-covered watershed with predominantly well-drained soils in north-central Mississippi.

Identical treatment of a catchment whose soil had a shallow dense layer increased overland flows, peak flows, and sediment production but did not influence stormflow volumes. The largest sediment production (almost 3 tons/acre) came during the first year after burning from one catchment in which a small gully was reactivated.--SO (79).

3. PREVENTING WATERSHED DAMAGE

Measurements made on the effects of roads and forest-cover changes on sediment yields in small forested watersheds in the Colorado Rocky Mountains indicate that careful but reasonable erosion control measures prevented excessive sediment yield. Annual yields averaged 200 pounds per acre in the years during and immediately following logging and decreased rapidly in subsequent years to only 43 pounds per acre which compares favorably to yields on undisturbed watersheds.--RM (92).

Returns of pink and chum salmon during and after logging confirm that timber harvesting in southeast Alaska need not damage salmon streams when logging is carefully done. In cleared watersheds the suspended sediment concentrations increased during logging, especially during road construction; but the increases were not significant when compared with stream sediment in an unlogged watershed. Cutting increased stream temperature up to a maximum of 9° F. in the summer months, and the maximum average monthly increase was 4° F. Winter temperatures were little affected.--PNW (98).

Length of time for revegetation following logging and broadcast slash burning was determined on plots in three areas in the H. J. Andrews Experimental Forest in western Oregon. Observations were made the year prior to cutting the old-growth Douglas-fir-western hemlock stand and during each of five growing seasons following. Revegetation amounted to 15 percent total plant cover the first year after slash burning, 49 percent cover after the second year, and 80 percent by the fifth growing season. Since plant cover curtails erosion and stream sedimentation, the length of time necessary for reestablishment of vegetation is of vital concern to land managers.--PNW (84).

(For additional items relating to II F 2 see paragraphs under II G 3; to II F 3, see under II G 3.)

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G. Bettering Silvicultural Systems

1. Natural Regeneration

Following strip clearcutting in northern Idaho, regeneration consisted primarily of subalpine fir and mountain hemlock on areas without site preparation. Prescribed burning or bulldozer scarification produced 2 1/2 times as much western larch as no treatment. The treatment also increased the ratio of spruce to fir, and resulted in small increases in

Douglas-fir and grand fir. The more diverse species composition resulting from site preparation provides greater silvicultural flexibility for timber and other products as well as improved aesthetic possibilities. --INT (4).

Study of 12- to 15-year-old stands in the western larch type of Montana showed that site preparation influences stand development past the regeneration period. Larch regenerated abundantly where prescribed burning or mechanical scarification reduced competing vegetation. Larch later become dominant because they grew twice as fast on prepared as on unprepared sites. With little or no site preparation, Douglas-fir grew faster than larch. These results provide a means for encouraging the species that will best meet management objectives.--INT (10).

Large openings in lodgepole pine stands on flat areas in the pumice-soil region of south-central Oregon often are difficult to regenerate, apparently because of low night temperatures. Pumice soils exhibit wider fluctuations in surface temperature than denser mineral soils. To counteract this temperature problem, clearcut strips should not be wider than twice the height of the stand. If wider, the strip centers should be planted.--PNW (6, 7).

Recent research and observations indicate that natural Engelmann spruce regeneration in clearcut openings in the central Rocky Mountains is generally restricted to the opening margins. A 10-year study of seed production, dispersal, and seedling establishment suggests that (1) seed supply is not the factor limiting success of regeneration in small openings; (2) some type of seedbed preparation is needed; and (3) new seedlings need protection from adverse environmental factors. This study provides basic knowledge needed to work out methods for the natural regeneration of Engelmann spruce.--RM (1).

Long-term experiments in the western white pine type show that prompt and adequate regeneration depends mainly upon site conditions. On moist northerly sites, the silvicultural systems tested (all even-aged) produced adequate regeneration in 5 to 10 years. On drier southern exposures, the regeneration period was prolonged to 20 years or more under both even-aged and uneven-aged systems. Selection cutting on these drier sites favored nearly pure fir.--INT (3).

Loblolly pine seedlings become established under a wide range of overwood density on many dry sites of the lower Piedmont. A study to find out how different-aged understory seedlings respond to release demonstrates that an overwood density of 40 square feet of basal area or less gives best results. These findings will help forest managers to plan harvest and regeneration cuts.--SE (5).

When longleaf pine is reproduced by the shelterwood method it is necessary to burn the seedbed several times to get enough advance regeneration for the new stand. An Alabama study showed that burning did not increase mortality of seedlings already established under canopy densities of 10 to 60 square feet of basal area per acre. The average mortality with a cool winter fire was only 4 percent.--SO (9).

Many northern red oak seedlings become established under mature oak stands in the southern Appalachians, but few become a part of the new stand following clearcutting because of competition from other vegetation. Seedlings were released from overstory and understory competition but neither treatment nor the combination of treatments significantly improved survival. Surviving seedlings however, grew up to 3 times faster after overstory release, and they showed response to understory treatment. Even so, it will be necessary to develop special treatments to speed red oak seedling growth or to hold back competition on good sites.--SE (2).

Disturbed or mineral-soil seedbeds commonly are recommended for regenerating yellow birch. Recent information from the Lake States, however, shows that the appropriate seedbed condition varies with site conditions. Mineral-soil seedbeds are important on dry sites or during dry periods but unnecessary in moist, partially shaded environments. These results enable forest managers in many instances to avoid the cost or inconvenience of seedbed preparation.--NC (12).

Better information is needed to determine the best season to log in order to reproduce the highest proportion of desirable species. A study of yellow-poplar in West Virginia disclosed that seedlings germinating in May and June survive about 2 to 3 times as well as those appearing after August 1. Harvest cuts should be made in the fall and winter to encourage maximum germination and survival.--NE (11).

Seed production information provides the basis for planning regeneration cuttings, seed collection operations, and seed orchard requirements. During a heavy seed year, a mature stand of western hemlock and Sitka spruce in southeast Alaska produced 131 pounds of seed per acre. The seed averaged 63 percent sound. Seed fall was influenced by weather conditions and extended over a period of many months.--PNW (8).

2. Silvicultural Methods

A comprehensive summary now is available on the silviculture and management of oak forests in the Lake States. Site appraisal, growth and yield, and cutting and regeneration methods are presented. Cost and return estimates are given for various sites and management alternatives. The summary provides a valuable management tool for forest managers in the Lake States.--NC (13).

Two new guides for field use summarize available information on the silviculture of important forest types in the Northeast. A guide on northern hardwoods covers procedures for diagnosing silvicultural needs and applying appropriate treatments under both even-aged and uneven-aged systems of timber management. A paper birch guide provides suggestions on management for esthetic purposes as well as recommendations on timber management.--NE (15, 16).

Shelterwood cuttings are effective in regenerating sugar maple and yellow birch on well-drained northern hardwood sites and somewhat poorly drained hemlock-yellow birch sites in the Lake States. The proportion of yellow birch reproduction can be increased over 4 times by scarification and chemical control of the understory in hemlock-birch stands. These treatments are somewhat less effective on northern hardwood sites. These findings add shelterwood cuttings to the silvicultural systems for management of northern hardwood, coupled as necessary with scarification and understory treatment to manipulate species composition.--NC (16).

3. ECOLOGICAL RELATIONSHIPS

Information on the vegetation of the Pacific Northwest has been fragmentary, scattered, or unpublished. A major summary is now available presenting this information within a classification system based on vegetation zones. The summary serves as an introduction to the plant ecology of Oregon and Washington, as well as a frame of reference for future research.--PNW (17).

The multiple-use management possibilities of a forest ecosystem depend upon the occurrence and distribution of the native trees and shrubs. On the Penobscot Experimental Forest in the spruce-fir region of Maine, 103 species of woody plants comprising 41 trees, 60 shrubs, and 2 vines have been found. This information provides a base for evaluating future trends in vegetation, and also illustrates the broad array of potential timber, esthetic, wildlife, and botanical values that characterize the spruce-fir forest.--NE (22).

Those who work in the hardwood forests of the South have been hampered by the lack of accurate descriptions of newly germinated seedling trees and shrubs. Now a research paper includes photographs and description of characteristics useful in identifying germinants and first-year seedlings of 68 species. This publication enables forest scientists and silviculturists to make early evaluations of the success of regeneration treatments.--SO (18).

Successional trends in forest stands often produce, or reflect, important physical and biological changes throughout the ecosystem. A study of forest succession along the Chena River in Alaska shows that stands of willow and balsam poplar early in the successional sequence are associated with deeper, more rapid soil freezing. Later in the successional stages spruce stands exhibit a continuous frozen soil layer, because of delayed thawing. This reduces site productivity. This information suggests that appropriate stand management may help to both retard development of permafrost and maintain site quality.--PNW (24).

For effective resource management, natural succession and the character of preclimax and climac forests must be understood. Washington State University scientists, supported by a Forest Service grant,

described in detail more than 70 forest stands approaching climax in the Wind River Mountains of Wyoming. As a result, five major forest habitat types were identified. These provide a basis for ecologically sound forest management practices and for further basic research on forest ecosystems.--WO (21).

Land subjected to wildfire in Hawaii is esthetically unpleasant and can be eroded during intense storms. A study of post-fire surface conditions showed that fireweed provided early protection cover to the soil and that aerially seeded grasses and legumes were readily established.--PSW (25).

Breakage of 26 percent of the stems during the winter of 1967-68 shows that snow and ice damage is a major ecological factor that must be considered in managing white and black spruce stands in interior Alaska spruce forests. This broken material contained an estimated 6-10 percent of the nitrogen, 10-19 percent of the phosphorus, and 10-15 percent of the potassium in the nutrient capital of the above-ground portions of the forest.--PNW (23).

Productivity of lowland areas along the Oregon coast is largely determined by the depth to water table. Average winter water-table depths were related to the density and petiole length of skunkcabbage coupled with the presence or absence of slough sedge. Using these relationships, water-table depths can be indirectly estimated from a single vegetation survey. Thus, the need for time-consuming direct measurements of water-table depth is eliminated.--PNW (20).

Productivity of lowland sites should be greatest where water-table depths and water-table tolerances of species are optimally matched. A controlled study showed that Douglas-fir seedlings are very intolerant of shallow water tables; whereas, lodgepole pine, western redcedar, red alder, and Sitka spruce are sufficiently tolerant to be favored over other species on such sites.--PNW (19).

(For additional items relating to II G, see paragraphs under III A 1; to II G 2, see under I B 1 and 2, II B 7 and 8, and III A 3; to II G 3, see under II B 7.)

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H. Improving Use of Wood

1. WOOD AND TIMBER QUALITY

One of the world's great collections of woody plant material was obtained by the Forest Service from Yale University. Included were some 55,000 wood specimens representing more than 14,000 tree species and some 25,000 herbarium specimens. Now combined with the Forest Products Laboratory's own collection representing some 6,000 species, it constitutes by far the world's largest, best, and most useful single collection. It will provide great opportunities for research in a highly specialized field.--FPL.

Sugar maple defect guide contains colored photographs showing exterior indicators and their associated interior defects. This manual better provides foresters and processors with the accurate correlation necessary for good management and utilization. Both natural and mechanical defects are illustrated. These photos will be especially helpful in training log and tree graders, and should facilitate the development of better grading systems in the future.--NC (27, 36).

A high-speed computer program was developed that rapidly and precisely grades hardwood boards in accordance with NHLA grade rules. The system involves mathematical description of limitations on the number and size of cuttings for a given grade, and coordinate location of board defect positions. The program is a vital step toward a computer-controlled manufacturing process. In a test run of 450 boards, grading was accomplished in about one-quarter second per board--all without a single error.--FPL (22).

Mechanical and physical properties were compiled for 120 species of tropical hardwoods of possible interest for import. Emphasis is given to those properties that affect their utilization, and suggested kiln drying schedules are included.--FPL (17).

A system for grading inland Douglas-fir trees to reflect lumber value was approved as Forest Service standard. Other Federal agencies and industry cooperated in developing the system. It is a continuous grading system, employing only five variables (dbh, height, basal scars, percent defect, and size of largest limb on butt log) in the estimating equations that predict both tree value and volume.--PNW.

A grading system for eastern white pine logs was approved as standard. This discrete system is based on the lumber outturn from over 2,800 logs from New England, Lake States, and the southern Appalachians.--NE.

The wood anatomy of 10 southern pine species has been definitively described. This description will be vital to their efficient use as an industrial raw material. The research indicates the wood of these species cannot be distinguished, even with the electron microscope. Although positive species identification was unsuccessful, there were a number of significant findings of interest to wood anatomists.--SO (9, 13).

2. WOOD PROCESSING AND WOOD PRODUCTS

Conventional resorcinol and phenol adhesives do not bond treated wood effectively. One resorcinol adhesive, specially formulated with high formaldehyde content for bonding ammonium salt-treated wood, met the minimum requirements of commercial standards. These findings now make feasible construction of laminated timbers with higher resistance to fire.--FPL (93).

Variation in composition is supected as the major cause of variable performance of creosote in marine exposures. New analytical methods can characterize trace components that may lead to more predictable durability in severe tropical marine exposures.--FPL (44, 45).

For large signs, regardless of geographic location, the best material is medium-density, paper-overlaid plywood. Vertical-grain boards are best for slat signs. Guides for selecting substrates and finishes, as well as procedures for routing and finishing, should improve performance of the thousands of rustic signs in recreational areas.--NC (57).

A computer program has been developed to give the most efficient method of obtaining specified products from lowgrade hardwood logs. A short-log sawmill was designed to illustrate most efficient use of the computer program. The combined techniques will enable economic use of extremely low-grade hardwoods.--NE (90, 91, 92).

Drying defects of southern pine studs from veneer cores were reduced by half when studs were restrained during drying and steaming at 240° F. Production was increased sharply by reducing drying time from 100 to 24 hours.--SO (70).

A 10-minute treatment in saturated steam at 360° F. effectively reduced thickness swell and springback in exterior particleboard. Treatment has little adverse effect on strength properties, and results are not influenced by species, resin content, and particle shape. Stabilization greatly enhances feasibility of utilizing various forms of waste wood in particleboard for exterior applications.--FPL (66).

Presurfacing of red oak together with improved temperature, humidity, and air velocity conditions reduced drying time by about 30 percent without increase in degrade. This increased efficiency will reduce processing costs and increase production.--FPL (78).

Detrimental thickness variations in rotary-cut veneer of four species were found related to forces acting in the lathe during the cutting process. Critical adjustments of pressure bar, nose bar, and knife carriage were defined to reduce variation and improve quality and control.--FPL (77).

A 3-year study at the University of Florida proved the feasibility of using a low-profile, wood, plenum floor system in single-family houses in Florida and similar warm, humid areas of the South and Southwest. Tests showed this system to be efficient for both heating and cooling. The plenum remained dry year-round and the living environment in the house was entirely satisfactory. This flexible system can be used with a variety of construction techniques and house designs.--SE (102, 104, 106, 112, 113).

A survey of Florida builders, architects, and homeowners showed favorable reaction to and general acceptance of a low-profile, wood, plenum floor system. A related survey of code enforcement officers in nine major Florida cities revealed that the under-floor plenum concept is acceptable in all cities surveyed except Miami.--SE (104).

A factory-fabricated, wood foundation system for a 1,000-square-foot basement cost $280 less than a conventional concrete block system, installed. Erection time for the wood foundation was 30 man-hours compared to 88 for the concrete block foundation. The wood foundation offers other potential advantages such as complete house construction by a single craft, less susceptibility to delay by inclement weather, and greater comfort in the living space below grade.--WO (114).

Spruce (red, white, and black), one of the most plentiful northeastern softwoods, is currently used principally for pulp. Research demonstrated technical feasibility of producing eastern spruce plywood, and a survey of contractors and architects indicates high acceptance of the product provided it bears the APA grade stamp. In general, spruce plywood has good potential for both structural and decorative uses and can contribute to the supply of construction materials.--NE (122).

Preliminary analysis indicates that bark is a cheaper source of power than gas in the Intermountain area. Improved bark burning boilers are capable of meeting air pollution standards enacted in Montana in 1967.--INT (109).

Farmer Cooperative Service and Forest Service jointly developed guides for determining feasibility of, and organizing forestry cooperatives. Future timber needs will place greater demands on production from small, nonindustrial forest ownerships. There is a strong need for cooperative enterprises for harvesting, processing, and/or marketing products from these lands.--NE (103).

With impending increase in demand for homebuilding materials, eastern spruce and hemlock are potential souces of building lumber in the Northeast. One deterrent is poor air-drying conditions during winter months. Research on low-temperature drying showed a 50 percent reduction in drying degrade but a 20 to 80 percent increase in drying cost compared to ordinary air drying. Where air-drying space is scarce, and when rigid quality standards and short delivery schedules must be met, low-temperature drying provides a way to add these species to the supply of needed building materials.--NE (115).

3. WOOD FIBER PRODUCTS

In a typical kraft pulping process, 40 percent of the total carbohydrate, including 15 percent of the cellulose, is lost through chemical degradation. This can be partially prevented and pulp yields increased by chemical modification of the wood carbohydrates. Treatment with borohydride solution was the most effective method. This could lead to new, higher yield pulping concepts.--FPL (134, 160).

No discarded paper and wood products, and relatively little metal and glass are now being reclaimed from urban solid wastes. The Forest Service, HEW's Bureau of Solid Waste Management, and Interior's Bureau of Mines have agreed formally to plan a joint attack on this problem. Several grades of paper have been made from wood fiber reclaimed on an experimental basis from municipal refuse. These initial steps form a foundation for developing a total system for recycling waste and reducing disposal problems.--FPL(125).

Water tupelo presently are cut near the top of the butt swells which may be as high as 8 feet above ground, or they are felled and bucked to leave

the buttressed base. In anticipation of increasing demands for pulpwood, bleached kraft and neutral sulfite semichemical pulps were made from butt swells of water tupelo. The pulps were good quality demonstrating the suitability of utilizing this waste material as pulpwood.--FPL, SO (130).

Sodium hydroxide can be substituted for the conventional sodium carbonate as a buffer in neutral sulfite semichemical pulping. This practice would take advantage of the lower price of sodium hydroxide and decrease the amount of inert gas to be vented. If one-half of the NSSC pulpmills in the U.S. used this process, the saving would amount to $750,000 annually.--FPL (129).

4. WOOD CHEMISTRY

Pulpwood chips, stored outside, are subject to losses in wood substance ranging from about one percent per month to total loss by spontaneous combustion. Initial heating in the chip pile is caused by living cell respiration. Heating and deterioration in the pile can be controlled by applying the pulping byproduct, kraft green liquor, to the chips.--FPL (163, 164).

Under-utilized processing residues--bark, sawdust, chips, shavings, and lignin--constitute both a major disposal problem and a potentially valuable resource. Comprehensive reviews are now available that summarize the current knowledge of these materials. Detailed descriptions of the resource, estimates of available quantities, methods of utilization, and lists of references are given. They provide a better basis for increasing utilization and for diminishing waste.--FPL (147, 148, 149, 150).

Spent liquor from the sulfite pulping of hardwoods commonly contains 2 to 6 percent dissolved xylose sugar. Stream disposal of this liquor constitutes pollution of the water and a waste of potentially valuable raw material. Furfural was produced from samples of waste sulfite pulping liquors, and the economics calculated appear to be favorable for commercial application.--FPL (170).

5. WOOD ENGINEERING

Applications of glued-laminated timbers, now commonly including finger-jointed boards, involve cyclic loadings. Tests at stress levels of 40 to 90 percent of static strength showed that fatigue strength in tension parallel-to-the-grain for finger joints at 30 million cycles is about 40 percent of static strength. This is about 20 percent less than for a 1:8 slope scarf joint.--FPL (173).

Current design criteria on strength characteristics of glued-laminated construction are based on data from tests on relatively small members. Data from tests of commercial-size beams up to 50 feet in length, laminated according to current industry specifications, are now available to aid in development of more exacting design criteria for large glued members.--FPL (174).

Present practice is to position boards in glued-laminated members based on visual grade only. Use of both modulus of elasticity and visual grading as criteria for selecting quality laminations for highly stressed areas results in stronger and stiffer wood members.--FPL (189).

The extensive Appalachia highway construction program created a substantial need for wood posts. Recent studies provide data for appraising strength, stiffness, and energy-absorbing properties of three Appalachian species as a guide to their performance and possible utilization for this purpose.--FPL (177).

Package cushioning design has been based on response of cushions alone, and has ignored effects of the container on shock transmitted to the packaged article. Studies reveal a direct relationship between rigidity of the outer shell and severity of shock to contents.--FPL (180).

No satisfactory test procedure has been available to measure adequacy of adhesives for use in corrugated board exposed to wet conditions. A new cantilever beam test now combines simplicity, economy, and good reproducibility of results in a method that will enable manufacturers to eliminate inadequate adhesives.--FPL (183).

Safe use of hardboard as a load-carrying element in construction requires development of reliable design stresses. Fundamental information now available on effects of rate, duration, and repetition of load enables more accurate assignment of stress values. The research indicates that behavior of hardboard is very similar to that of solid wood.--FPL (187).

Tensile strength of lumber is an important property in applications such as trussed rafters and glued-laminated tension members. A new technique involving combined use of modulus of elasticity and bending-strength ratio shows promise as an improved nondestructive indicator for predicting tensile strength.--FPL (190).

(For additional items relating to II H see paragraphs under III A 1 and III C; to II H 1, see under III A 3.)

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I. Remote Sensing Methods

Earth orbiting space programs provide an unusual opportunity for obtaining forest resource information. A preliminary systems analysis in cooperation with NASA has already produced programs for handling map coordinate data and for automatic mapping of forest resources. Using standard aerial photographs, ground measurements, and a four-stage sampling inventory, Forest Service scientists estimated timber volume on the Consumnes Working Circle of the Eldorado National Forest with a sampling error of only 7.5 percent. Progress to date reveals the great potential of space-age forest inventories--PSW (3).

The tremendous capabilities of spaceborne or airborne remote sensors to gather data on earth resources has generated enthusiasm among scientists, but several major problems are unresolved. For the first time we have put together a complete theory on utilizing information from images of increasingly finer resolution. With this information formulas have been developed to optimize the allocation of forest inventory funds.--PSW (1).

Even though techniques and equipment for making maps from aerial photographs have become very sophisticated, resource managers at field locations often need to make their own maps. To meet this need, mensurationists in California have devised a portable system for measuring and mapping from aerial photographs using a stereotope plotter and a portable desk-top computer. Only a cursory knowledge of the principles of photogrammetry is needed to use the system.--PSW (2).

During 1969 an improved bi-spectral electronic system for fire detection and mapping was developed and installed in a new twin propjet aircraft. The system operating with a spectral response of 3 to 4.1 microns and 8.5 to 11 microns and a target discrimination module provides sharp imagery of fires and terrain. A computer analysis of the system indicates a performance potentially 10 times better than single-channel systems. A computer fire detection model using digital simulation has been developed for support of an operational fire detection experiment to be performed in 1970 in an 8,000-square-mile test area in the Northern Rockies.--INT (5, 6).

An inexpensive low resolution fire spotter has been developed for use on low-flying aircraft. Its purpose is to locate previously detected fires that cannot be seen visually by smokejumpers or other fire attack forces. Commercial manufacture of the fire spotter and operation field testing will be started in 1970.--INT.

A lightning recording system has been designed to measure the electrostatic field changes associated with discharges occurring within about 25 miles radius of the recording site. In addition, the system detects and records luminosity, thunder, and the flash image of all discharges occurring within the same radius. Designed primarily to measure changes in lightning during cloud-seeding experiments, the system can document features present in discharges causing forest fires. Modification and testing through three seasons' use have resulted in a compact, relatively trouble-free unit for ground-based lightning studies.--INT (4).

To provide full mobility for detection and measurement of lightning an electronic sensing and recording system has been developed. The system was employed in lightning studies and weather modification experiments in 1969. In cooperation with the BLM, the lightning sensing system was installed in a jet aircraft to evaluate its performance for support of fire detection operations in Alaska.--INT (II J, 2).

For the first time, a space-age tool, the laser, was used on an experimental prescribed fire to demonstrate its capabilities. The test showed that the low-yield laser could measure flame velocity, density, temperature, resonance, and particle distributions.--PSW.

(For additional items relating to II I see paragraphs under I D 1 and II B 10 and 14.)

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J. Weather Modification and Weather Effects

1. WEATHER MODIFICATION

A Project Skyfire experiment involving 26 individual thunderstorms proved that massive cloud seeding modifies lightning. The results showed 66 percent fewer cloud-to-ground discharges and also a modification of the characteristics of long continuing current discharges from clouds massively seeded with silver iodide. Seventy five percent of the seeded storms yielded less total lightning than predicted by thunderstorm equations. Most important is the finding that the long continuing current in the type of lightning stroke most likely to ignite fires is reduced from 187 milliseconds for storms not seeded to 115 milliseconds for seeded storms. These results now provide the main scientific base for development of an operational system to prevent lightning fires.--INT (1, 2).

The characteristics of northern Rocky Mountain thunderstorms with and without hail were compared on the basis of visual observations of hail at the surface and electric field meter records of lightning frequency. Data from 25 natural thunderstorms in western Montana indicate that the hailstorms generally produced lightning at a higher rate and for a longer period than storms without hail. Of these 25 storms, the largest one produced the greatest number of lightning discharges and the largest hailstones.--INT.

2. FIRE AND FOREST METEOROLOGY

The new National Fire-Danger Rating System provides three basic fire control tools: Occurrence Index, Burning Index, and Fire Load Index. The Occurrence Index is a number related to the probable number of fires in a

rating area. The Burning Index is a number related to the potential containment job for a fire in the rating area. The combination of the two produces the Fire Load Index, which measures the total potential fire containment job for the rating area. All three indexes are relative; that is, a doubling of the index represents a doubling of the rated activity. Limited field trials of the new system will be conducted nationwide during the 1970 fire season.--RM.

To define a standard drying day for forest fuels, standard drying conditions in the laboratory have been related to the diurnal fluctuations of temperature and humidity. This relation may be used to compare the moisture change of a specific fuel during a specified time, or the time required to reach a specified moisture content, under field conditions, to the moisture change or time under standard conditions.--RM.

"Fire Weather," a 12-chapter text aimed at developing an understanding of basic fire weather information in the United States, has been issued as Agriculture Handbook #360. The first four chapters discuss the static properties of the atmosphere, such as basic physical principles, temperature, atmospheric moisture, and atmospheric stability. The next six describe atmospheric dynamics from general circulation and local winds through air masses, fronts, clouds, precipitation, and thunderstorms. Chapter 11 deals with the moisture response of dead and living forest fuels to changing weather conditions. The last chapter summarizes regional fire weather and important synoptic fire-weather patterns.--PSW (19).

Continuing drought in Georgia results in record fire business. The outstanding weather trend of 1967, rainfall deficiency, continued unabated over most of Georgia through all of 1968. Rainfall deficiencies of up to 18.8 inches were experienced, and drought indices in many parts of the State were markedly above their 10-year averages. Fire business in Georgia during 1968, was at its highest level in over 10 years, with 11,547 fires burning more than 73,000 acres. March, as usual, was the worst month when the average fire size was 9.3 acres for 3,773 fires.--SE (11, 17).

Sea breeze frontal passages, which may cause unusual fire behavior, occurred during all months of the year in a study at Harris Neck, Georgia, with over 100 passage days in a 1-year period. The sea breeze begins in the late morning or afternoon, when the effect on fire behavior could be most serious.--SE.

Meteorological effects of the March 7, 1970, total eclipse of the sun were documented in Georgia by the Project THEO surface network. All stations, operating at observational intervals as frequent as one minute, produced data which were virtually complete and error free. Changes in most weather elements lagged totality by 20 to 40 minutes. Temperature fell as much as 3.8 C., and relative humidity rose as much as 14 percent from the onset of partiality to the end of totality.--SE (22).

Lightning can cause insect infestations in Montana. Lightning damage to a struck ponderosa pine, the pattern of infestation in its bole by the pine

engraver beetle, and the success of the pine engraver infestation of surrounding sapling and pole-size trees were documented in western Montana. The struck tree became infested along its entire length by bark beetles, and 76 percent of the immature trees within 80 feet of the struck tree also became infested. Attacks tended to be more successful closer to the struck tree and in trees in relatively moist soil.--INT (II A 70).

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III. IMPROVING TIMBER PRODUCTIVITY AND EXTENDING SUPPLIES

A. Intensive Culture Methods

1. Site Evaluation and Soil Improvement

Guides for identifying phosphorus-deficient sites in the southeastern Coastal Plain are needed by forest land owners and managers. Results of seven experimental plantings of loblolly pine on wet sites showed that the phosphorus content in the needles is a good index of soil and plant phosphorus. Under conditions of severe phosphorus deficiencies, tree height at 3 years increased 82 percent when 25 or 50 pounds of phosphorus were applied to each acre at planting.--SE (12).

Some research suggests that results of applying supplemental nutrients to low-fertility soils in the Southeast vary by tree race. A study with slash pine compared the effects of fertilization and genotype. Dry weight of some seedlings was increased fourfold by fertilization, and the ability of this species to absorb nutrients did vary by seed source. Such work will lead to greater returns from genetic programs and investments in fertilization.--SE (9).

Forest fertilization is a promising cultural treatment, but nutrient requirements of trees must be known. Yellow birch seedlings grown in podzol subsoil from New Hampshire increased in height growth 10 times and net weight 14 times from the addition of nitrogen, phosphorous, and dolomitic limestone. Fertilizer treatments like those tested should help to correct shallow rooting and slow growth common to yellow birch in New England.--NE (3).

Forest fertilization in the Pacific Northwest with nitrogen applied at 150 to 300 pounds per acre can increase Douglas-fir volume growth by up to 100 percent. The average is about 30 percent. These findings justify larger investments in fertilization research and practices to increase wood supplies.--PNW (11).

Seedlings of yellow-poplar and white ash grew significantly better in the undisturbed top layer of a forested silt loam soil than in the lower layers. This behavior implies that loss of the original surface soil is a major cause of poor survival and growth of hardwoods planted on certain upland oldfields. Improvement of physical and biological conditions of these soils, as well as their fertility, is required for successful hardwood reforestation.--NC (2).

In north Alabama, pine has been favored over hardwoods; yet, moist lower slopes and narrow stream bottoms can produce high-value hardwoods. After 10 years, a study has shown the potential for yellow-poplar

by broad site classes. These results will help land managers select the right sites for planting yellow-poplar.--SO (10).

Productivity of lodgepole pine stands in central Oregon cannot be delineated by conventional soil series classifications. Within one soil series (Lapine), productivity was related to the thickness of the A and AC horizons. However, the understory plant community provided the best indication of productivity measured in terms of basal area, site index, or volume increment. Productivity ratings based on plant community should be especially useful in areas where site quality cannot be directly determined from soils or measurements on standing trees.--PNW (14).

Interest in the intensive culture of species such as sycamore for maximum fiber yield is great, but the effect of intensive culture on wood properties has not been determined. Various factors affecting wood quality were examined in a 7-year-old sycamore planting in Georgia that had received 27 combinations of fertilizers. The results indicate that the diameter growth of young sycamore can be increased up to 50 percent through fertilization without lowering wood quality.--SE (8).

The effects of nutrients on wood quality need assessing to aid in planning fertilization to improve tree growth. Laboratory tests of 2-year-old western larch seedlings revealed that specific gravity and breaking strength, among other properties, were reduced by certain nutrient deficiencies. This emphasizes the need to provide a balanced nutrient supply to maintain wood quality in larch.--INT (7).

New information is available on the patterns of foliar nutrient content in yellow birch. Early season concentrations of 5 microelements usually decrease. Later they level off or increase. When foliar manganese is 5 times the apparent upper acceptable limit, toxicity may result.--NE (4).

Nutrient analysis of tree leaves can be a very helpful tool in forest management, but the actual nutrient content varies during the year and by location within the tree. Investigation of nutrient content in loblolly pine needles in the Piedmont of North Carolina and South Carolina shows that it is best to collect samples in the winter from the first flush of the previous spring near the treetop. This provides a standard procedure for sampling loblolly pine foliage.--SE (13).

Nutrient content of tree foliage is useful in studying and evaluating nutritional deficiencies. Nitrogen and phosphorus varied appreciably among planted eastern cottonwood according to soil moisture conditions and tree genotypes (clones), which showed differences in nutritional requirements. Thus, in sampling foliar contents, these two factors must be standardized or considered.--SO (1).

Naturally dense or compacted soils sometimes limit tree establishment and growth. A greenhouse study determined which northwestern tree species are most tolerant of dense soil. The roots of lodgepole pine, Douglas-fir, red alder, and Pacific silver fir penetrated soils that were too dense for root growth of Sitka spruce, western hemlock, and western

redcedar. The former species are better than the latter for regenerating logging roads, landings, and hardpan areas where compacted soil is a problem.--PNW (6).

Old fields in the Virginia Piedmont often are planted with a number of different pine species, but effects of planted trees on the surface soil are unknown. Differences in mineral-soil conditions under 16-year-old loblolly, shortleaf, Virginia, and eastern white pine plantations were not yet very evident; however, in weight of organic material on the forest floor, loblolly had roughly twice that of white pine. Other species were intermediate. Nutrient contents of the forest floor varied also. These findings provide some preliminary conclusions about long-term effects of tree species on soil properties.--SE (5).

2. ARTIFICIAL REGENERATION

Interest in planting sycamore is at an all-time high in the South. Nursery production has increased 1,500 percent in 10 years. Research and experience with this species has been summarized to meet the need for information on plantation establishment and care. Predictions are that a successful sycamore plantation will yield 2 to 5 times more wood per acre than natural forest.--SO (16).

White spruce seed usually is stratified for 30 days or cold-soaked for 10 days to break dormancy before sowing. But seed that was soaked for 2 days, and then exposed to artificial light for as little as 2 1/2 hours, germinated as well as seed treated in the usual way. This provides a quick pretreatment method potentially useful to nurserymen for testing seed or quickly resowing seedbed failures.--NC (24).

Yellow and paper birch seed have been successfully stored for 8 years in closed containers at 36-40° F. Individual seed lots, however, varied so much in their storage life that it is recommended that all birch seed lots be tested for germination before being used.--NC (19).

Of the southern pines, longleaf pine seeds are the most difficult to store. Three studies with this species show that high viability can be maintained for at least 10 years by drying the seeds to a 10 percent moisture content and storing them at 0° F. These results will be useful to researchers and to nurserymen who must store seed for many years.--SO (15).

Germination of seed of Douglas-fir and many other species, is inhibited by seed dormancy. A study of metabolic activities shows that dormant Douglas-fir seeds exhibit low levels of metabolism even under conditions favorable for germination. Stratification results in increased respiration and the breakdown of fatty substances. Further investigation of the reasons for the breakdown of fats may lead to better treatments for breaking seed dormancy.--PNW (25).

Since the proportion of filled sugar maple seed varies from about 20 to 74 percent, eliminating unfilled seed would save sowing and storage costs

and reduce variability in nursery germination. The use of pentane to separate unfilled seed by flotation has proved 95 percent effective, and it does not harm viability.--NE (18).

Protecting nursery seedbeds with temporary plastic greenhouses in Lower Michigan increased the net, first-year catch of jack pine and red pine up to 3 and 7 times, respectively, over that of unprotected seedbeds. This technique will ensure maximum utilization of limited or high-value seed, especially genetically superior seed.--NC (23).

Use of bare-rooted planting stock should substantially reduce nursery and planting costs in Puerto Rico, but early trials of this method with Caribbean pine had resulted in extremely poor survival. Several types of shoot pruning of seedlings resulted in survival of no better than 46 percent; thus, more research is needed to develop methods for using bare-rooted stock.--ITF (22).

Aerial broadcast seeding with southern pines has been very successful, but it has been wasteful of seed and imprecise in planting. The feasibility of aerial seeding in rows was established in a cooperative study with Auburn University. Further refinements of technology should lead to more economical use of genetically improved seed, establishment of stands in rows to aid future mechanized harvesting, and better control of initial stand density.--SO (21).

During the early years of commercial forest planting in the South, the urgent questions were what, how, and when to plant. Results of experimental plantings maintained through full pulpwood rotations of 30 years or more have shown that spacing, soils, and genetic characteristics substantially affected survival, growth, yield, and sometimes disease incidence. This pioneer work, begun in 1922, continues to be of inestimable value.--SO (28).

Survival of planted southern pines varies considerably between nurseries and even within a nursery, but factors responsible for such differences had not been identified. Using loblolly pine seedlings from three different nurseries, it was found that seedlings with mycorrhizae survived 37 percent better than seedlings without mycorrhizae. Increasing mycorrhizal infection through nursery practice should produce higher quality seedlings that will give consistently good field survival.--SO (27).

Does it pay to replant failed spots in southern pine plantations? Long-term observations through a complete pulpwood rotation in Louisiana showed that replacements made up only 4 percent of final slash pine pulpwood volumes, and 1 percent or less of longleaf and loblolly volumes. Thus, replacement planting is unlikely to be profitable except perhaps for slash pine at 8- by 8-foot spacing.--SO (29).

Hawaii has no native conifers and must import more than 90 million board feet of softwoods per year. Experimental plantings on Maui have shown after 9 years that slash and loblolly pines have grown twice as fast as those in the southern United States. Monterey pine is growing at a rate similar to that in plantings in New Zealand, Australia, and South Africa.

Caribbean pine has poor form. Based on these early results a 30-year rotation is predicted, but wood quality and potential injurious agencies must be evaluated before these species can be recommended.--PSW (26).

The infertile, droughty soils of the Florida sandhills produce little of value. Choctawhatchee sand pine, a little-known tree, seems well-adapted to such sites. A plantation produced 32 cords of wood per acre in 28 years.--SE (17).

Mountain-laurel and rosebay rhododendron lend beauty to the landscape in the Southern Appalachians, but they also sometimes form dense thickets that inhibit tree reproduction. A fire prescribed under specific burning conditions on an experimental area killed the tops of 70 percent of the unwanted shrubs. Eastern white pine subsequently planted on the area is growing well. Burning may prove to be a useful silviculture tool to control laurel and possibly rhododendron temporarily.--SE (20).

Forest managers in Hawaii would like to know if stump sprouts of tropical ash can be used in management. Five years after thinning, 70 percent of the stumps had produced an acceptable sprout. It should be possibly to rely on stump sprouts to regenerate tropical ash plantations following cutting to save reestablishment costs.--PSW (30).

3. STAND IMPROVEMENT

Fusiform rust is the most serious disease of slash pine plantations, and pruning infected limbs has been recommended to reduce damage to the trunk. A study to test this recommendation showed that the reduction of the incidence of stem infection was not enough to warrant pruning large plantations. However, pruning may still be justified for the small owner who wants to combine rust reduction and clear wood production.--SO (33).

What are the benefits from thinning black willow stands in the Mississippi River Valley? Density studies provide some answers. Growth of individual trees was increased 1 1/2 to 2 times by heavy thinning, and residual densities of 60 to 90 square feet are recommended, depending upon site. Major benefits from thinning black willow are to utilize trees that would otherwise die, to stimulate diameter growth, and to shorten rotations.--SO (37).

A study of site preparation on slash pine planting sites in Florida indicated that effectiveness is related to degree of disturbance. Bedding--contiguous fireline furrow-slices chopped with a brush cutter--resulted in roughly a third more height growth than no treatment. Clearing was the second best treatment. Bedding, however, is cheaper and is recommended.--SE (39).

Many foresters question the value of wide spacings for slash pine to produce sawtimber and veneer timber. A comparison in Georgia showed that spacing had no effect on summerwood percentage or specific gravity. Thus, maintaining dense stands to produce dense wood is not justified.

Based on volume production, clear material can be produced cheaper by wide spacing and artificial pruning than by close spacing and natural pruning.--SE (32).

Under ideal conditions loblolly pine regenerates abundantly and often creates dense thickets of slow-growing trees. A trial of precommercial thinning in southern Arkansas in cooperation with Georgia-Pacific Corporation showed that machine plus hand thinning quadrupled merchantable pulpwood volume in 12 years because trees reached pulpwood size earlier. For best returns stands should be machine thinned when 2 or years old.--SO (36).

Moderate commercial thinning of young, merchantable ponderosa pine stands provides an intermediate income with only a small reduction in volume growth. Where 30 percent of the volume was removed, net annual increment averaged 300 board feet per acre, about 10 percent less than the growth on uncut plots and twice the growth of plots where 75 percent of the volume was removed.--INT (34).

Crop-tree thinning studies in the Pacific Northwest showed that diameter growth of young ponderosa pine crop trees can be doubled by cutting all trees within a 5- to 8-foot radius. Overstory removal produced an additional marked response, coupled with a moderate increase in height growth. These responses demonstrate the effectiveness of thinning or release programs in ponderosa pine.--PNW (31).

Response information on precommercial thinnings in young northern hardwoods in New England is rare. Heavy crop-tree thinning in a 25-year-old even-aged stand increased diameter growth by over 60 percent but the two other methods also stimulated growth. The results indicate that response to precommercial thinning is excellent.--NE (38).

Epicormic branching causes serious losses in the quality and value of hardwood trees. When crown removal treatments were applied to pole-sized sugar maple in northern Wisconsin, all visible dormant buds on the tree bole produced epicormic shoots. Thus, numbers of visible dormant buds provide some indication of sprouting potential; and weeding, thinning, or release treatments that maintain sugar maple crowns in vigorous condition should help limit epicormic sprouting.--NC (35).

4. ANIMAL DAMAGE

To avoid contaminating the environment with toxic chemicals, the search continues for safer and more efficient methods of protecting sown seed. Recent research shows that impregnation of Douglas-fir seed with endrin provides better protection against rodent depredation than the standard 0.5 percent coating. Thus, the chances of contaminating forest environments are substantially reduced. Endrin-impregnated or coated seed can be stored for up to 4 months, which extends the direct-seeding season.--PNW (47, 48).

In direct-seeding New England pines, heavy losses of both white and red pine seed occur to birds and small mammals even when the seed is treated with the recommended dosages of repellents. Seed losses were reduced from 52 percent to less than 3 percent when the seed was treated and covered with soil. A recently modified mechanized seeder provides a practical application of this finding.--NE (42, 43).

Chemical repellents for controlling animal damage to forests must be carefully screened before use to determine effectiveness and possible side effects. TMTD reduces browsing of conifer seedlings by rabbits, hares, and deer during the dormant season. It has low toxicity for animals and decomposes easily in the soil. A review article summarizes available technical information for its use.--PNW (46).

A cooperative survey in Oregon and Washington shows that animals and birds are causing substantial losses to both plantations and natural stands. About one-third of planted Douglas-fir seedlings and one-sixth of the ponderosa pine are damaged annually during the first 4 years after planting, resulting in mortality losses of 35 and 51 percent by species, respectively. Questionnaire returns indicate that animal damage--from deer especially--is more common in Oregon National Forests than in Washington.--PNW (40, 41).

Animal damage in the Douglas-fir region is of growing importance. Research at the University of California financed by a Forest Service grant showed that nitrogen fertilization of Douglas-fir seedlings increased their growth, protein content, fermentability, and acceptability to deer. This finding suggests that nitrogen fertilization practices to improve growth rates of Douglas-fir may result in increased deer damage.--WO (45).

The effect of severe winter browsing on rapidly growing sugar maple seedlings in northeastern Wisconsin appears silviculturally insignificant. After 5 years, dominant seedlings in unfenced quadrats were 1.6 feet shorter than fenced seedlings because of leader browsing, but rate of height growth and seedling density were not affected. Silvicultural treatments such as thinning and release that favor rapid height growth will help overcome deer browsing problems with sugar maple.--NC (44).

5. GROWTH REQUIREMENTS

Because sunlight is the source of energy for plant growth, it is one of the key factors affecting tree development. A study in the Lake States of the effects of sun and shade on yellow birch revealed that shaded seedlings were taller and had greater leaf areas and top/root ratios while seedlings in full sun accumulated more dry weight. This information provides a basis for designing shading treatments of given specifications for growing seedlings; it also adds to our understanding of the processes affecting seedling growth and survival.--NC (54).

Transpiration bears an important relationship to water use, as well as to physiological conditions within the tree. Leaf temperatures of cottonwood were shown to be (1) consistently lower than air temperatures in freely transpiring seedlings and (2) directly related to leaf-water deficits. Reduction of leaf temperatures through transpiration may be physiologically beneficial under the subtropical climate of the lower Mississippi Valley.--SO (53).

Information on the production and distribution of photosynthate helps provide a basis for understanding and controlling stem development and quality. The use of labeled carbon-14 proved 1-year needles of young red pine largely responsible for the initiation and maintenance of shoot elongation. Maximum photosynthetic efficiency in cottonwood seedlings coincided with a change in the direction of carbon-14 transport out of a new leaf from an upward to a downward direction along the stem. In artificially bent red pine, hemicellulose constituents within the secondary cell wall proved to be considerably different between compression and normal wood, whereas no such differences were noted in the primary wall.--NC (55, 58, 59).

A valuable segment of PL-480 research performed in Colombia was the development of methods for successfully culturing living tissues of Cupressus (cypress). A new, high mineral-salt medium was perfected that promotes callus formation and growth. With living explanted tissues, physiologists can study and analyze tree growth, reproduction, and aging processes without hindrance from other tree parts or environmental changes.--WO (51).

The exact nature of the root competition between ponderosa pine seedlings and grass is not fully understood. Investigations of these relations in Arizona reveal that grass roots start growth earlier and grow faster than pine roots and deplete soil moisture. Seedlings grown without grass competition showed eleven times as much dry weight as those with grass competition. This work explains why ponderosa pine should be planted only in grass-free areas.--RM (60).

Retarded early height growth is a major problem in the management of longleaf pine. Studies with a group of saplings in southern Mississippi indicate longleaf pine is capable of continued elongation throughout the growing season, given a favorable environment. The number of growth surges is determined by the tree's moisture regime and the amount of available photosynthate, with moisture regime being the more influential.--SO (49).

Competing vegetation, especially perennial grasses, takes soil moisture needed to establish ponderosa pine in the Southwest. Plots sprayed with dalapon to control the grasses had significantly more water in the upper 20 inches of soil--water available for the natural or artificial establishment of pine seedlings--than did plots that were scalped or left untreated.--RM (56).

Mycorrhizal infection of tree roots is known to increase growth rates of many species, but the mode of action is not fully understood. Yellow-poplar seedlings inoculated with live spores grew much faster than those inoculated with dead spores, showing that mycorrhizal infection, rather than associated substances, directly stimulates tree growth.--NC (52).

Little is known of the biochemical changes that occur during the germination of tree seeds. Activity of alcohol dehydrogenase, an enzyme regulating the production and oxidation of ethanol in living tissue, was demonstrated in germinating longleaf and slash pine seeds. This type of enzyme activity may reflect differences among species and races in site adaptability.--SO (50).

Epicormic branches account for a high percentage of defects in hardwoods. In order to understand the source and ultimately control epicormics, a 5-year study of bud development on sweetgum was conducted in the Southeast. Neither age nor bark thickness cause a reduction in numbers of suppressed buds; however, the area of maximum bud development gradually passes up the bole. Selection and breeding for strong inhibition of suppressed buds may improve the quality potential of sweetgum.--SE (57).

6. GROWTH AND YIELD

Complete yield information from intensively managed Douglas-fir stands still is unavailable. However, nine foreign production tables for Douglas-fir plantations converted to American units of measurement suggest that potential yields of thinned stands in the Pacific Northwest are at least 14 percent higher on an average site than currently estimated. Culmination of merchantable production under heavy thinning may occur at 65 to 80 years. This preliminary information provides a basis for choosing appropriate levels of investments for intensive management of Douglas-fir.--PNW (64).

Yield information for unthinned second-growth yellow-poplar stands of the Appalachians is needed for management decisions. Cubic-foot and board-foot yields have been related to age, site index, and number of trees per acre; predicted volume varied from actual measured volume by only 25 cubic feet or 350 board feet. With the information provided, the manager can determine the volumes of existing stands and what volumes can be expected at some future date.--SE (62).

The ability to estimate present and future stand volumes is an essential ingredient for scientific forest management. Equations have been developed from long-term growth data for loblolly pine in Georgia that explain 77 and 93 percent of the variation in board-foot and cubic-foot yields, respectively, of even-aged natural stands. The tables with their predictor variables of age, stocking, and site index will help forest managers decide when to harvest stands.--SE (63).

Little attention has been given to the management alternative which would minimize rotation length at some sacrifice of total yield. Loblolly pine plots in southeast Arkansas that had been thinned to 10 square feet of basal area per acre at age 9 had at age 21, 76 trees per acre with a volume of 6,400 board feet of sawtimber. Plots thinned to 85 square feet had only 300 board feet. Thus, in many places in the South, high-quality pine sawtimber might be grown on short rotations.--SO (61).

Intensive forest management depends heavily upon the ability of the forest manager to measure, control, and predict growth and yield. New stocking guides for both even-aged and uneven-aged stands of the beech-birch-maple type are now available as a result of research conducted in the Northeast. Careful control of stocking in hardwood stands by intermediate cuttings could double sawtimber production.--NE (68).

Regardless of thinning method, basal area growth of 20- to 40-year-old red pine plantations in the Lake States is nearly the same for residual densities ranging from 60 to 120 square feet per acre. However, most owners will find it profitable to leave 60 square feet residual density, because of greater diameter growth and a shorter rotation. Row thinning is recommended to minimize costs, facilitate harvest operations, and stimulate growth.--NC (66).

A recently developed approach for evaluating the stocking of forest stands should facilitate more precise control of the growing stock. This new measure of stocking basically is defined as the ratio of current growth to potential productivity for a given site. Procedures have been developed for sampling, summarizing, and interpreting growth data so as to facilitate use of this new stocking concept.--INT (69).

Productivity of grand fir sites can now be estimated more efficiently by measuring crown ratio in addition to the usual variables of tree height and age. Two computer routines and a graphical method have been developed to perform the required computations. The results, expressed in relative productivity or in annual cubic-foot growth per acre, should improve management planning.--INT (70).

Growth data for planted longleaf pine are scarce. A spacing study in Louisiana provides data to show that growth in fully stocked plantings averaged 2.7 cords per acre per year during the period from age 20 to age 30. So, despite the usual slow start, planted longleaf has potential for acceptable volume growth rates.--SO (67).

Thinned white spruce plantations grow well according to a study in northeastern Wisconsin. Mean annual increment up to age 38 among thinned plots varied from 94 to 110 cubic feet. Unthinned plots had at least 3 times the mortality as well as slower diameter growth than the thinned. The results show that white spruce is an acceptable species for reforesting appropriate sites, provided that thinning will be done.--NC (92).

Foresters need better information on diameter growth rates to improve growth predictions of hardwoods on a range of sites in the Appalachians.

A study of individual trees shows that species, site quality, initial diameter, and crown class can be used to predict accurately diameter growth rates. This information provides an improved predictive basis for judging which trees to cut.--NE (71).

Diameter growth rates of trees often are estimated by increment borings, which are time consuming and injurious to the wood. In northern Wisconsin, yellow birch trees with smooth or peeling bark grow about twice as fast as trees of comparable size with rough bark. Bark characteristics can now be used to select crop trees or quickly screen superior tree candidates without resorting to increment borings.--NC (65).

7. FOREST MEASUREMENTS

Optical dendrometers are coming into greater use in timber inventories, and comparability with existing methods based on volume tables is of considerable importance. Theoretical analysis shows that the two methods should produce comparable volume estimates. Thus, successive inventories should provide reasonable estimates of volume growth, even when the inventory method has been changed.--INT (73).

A new equation was developed to provide better estimates of cubic-foot volume in flaring Douglas-fir butt logs. The new equation has a standard error of 3 percent, whereas previous methods led to biases of 10 to 15 percent.--PNW (74).

Accurate estimates of bark thickness are required to determine actual wood volumes is standing trees. By measuring bark thickness from the actual wood surface radially outward to the contour of a tape wrapped tightly around the tree bole, maximum errors in bark measurement were reduced from about 0.6 inch to 0.2 inch in shortleaf pine. In eucalyptus trees, no differences were found in bark thickness among 12 positions around the tree circumference, indicating that bark thickness can be measured on either the uphill or downhill sides of the tree. These findings will improve the accuracy and efficiency of bark thickness measurements.--SO, PSW (78, 79).

Both theory and data have been lacking for methods to evaluate stocking in seedling-sapling hardwoods. Using data from young even-aged hardwoods in New Hampshire, the pattern of mortality was expressed as a mathematical process; this provides a means to estimate the probability that a plot now containing a given number of stems would remain stocked at some time in the future. Regeneration stocking guides based on equations developed in this study are given.--NE (77).

Sample trees and plots for research and inventory purposes often are measured during the dormant season. A study in northeastern Wisconsin showed that the diameters of five hardwood species shrink considerably during the dormant season as air temperatures drop below freezing. Errors of up to 48 percent in estimates of 5-year cubic volume growth

were attributed to this shrinkage problem. Measurement during early fall is recommended as standard practice to prevent these errors.--NC (76).

Sample surveys or inventories should be designed to obtain the greatest precision at least cost. Data from a spruce pine specific gravity survey in the Southeast showed that to achieve a given degree of accuracy, it was least expensive to take a relatively large number of sample plots coupled with a relatively small number of trees and cores per plot. The results provide a basis for designing efficient surveys of specific gravity, a characteristic that greatly affects pulping efficiency and yields.--SE (75).

8. MANAGEMENT PLANNING

Logging road systems on steep slopes in northern Idaho take 10- to 15-percent of the area out of timber production. However, measurements in well-stocked plantations of western white pine show that the additional volume growth on trees adjacent to the roads can offset the loss in area. On stable soils with good drainage characteristics, a well-designed system of narrow roads can produce multiple benefits with little or no loss in timber production.--INT (82).

Logging costs and production rates based on harvesting seed trees after the desired reproduction has become established are seldom available. Such a study in a mixed-conifer stand in California indicated that skidding production rates during seed-tree removal were 38 percent higher than similar rates during the original cut, even with special care being given to avoid damaging the regeneration. Seed-tree removal was both silviculturally feasible and economically profitable.--PSW (81).

Allocating timber management research funds is difficult because of both lack of data and complexity of the problem. A study of mathematical allocation models revealed that funds could be allocated to forest types so as to maximize expected returns from the research effort. These mathematical methods provide a means for objectively determining priorities in allocating research funds.--SE (80).

9. MAPLE SIRUP PRODUCTION

Maple sirup production today is only about one quarter that of the peak year 1860 but the decline has been checked as a result of recent improvements in the industry. Research in the Northeast is providing more improvements such as determining the proper depth of the tapholes. If sugar producers drill deeper tapholes, total sugar yield may be increased 30 percent.--NE (84).

Selection of sugar maples for superior sap-sugar production can now be made at the nursery level with a new method for mass testing 2- and 3-year-old seedlings. Sap-sugar demonstrations were made possible by using microtapping techniques, and artificially cycling the plants through

alternate freezing and thawing periods to induce sap flow. Although readings were obtained on most seedlings, some did not respond. The nature of the sap flow mechanism in some seedlings appears to vary with factors other than cold nights and warm days.--NE (83).

10. NAVAL STORES

Much of the variation in gum yields of slash and longleaf pine is due to tree size. But considerable variation occurs among trees of equal size mainly because of genetic differences in yielding ability. Data from selected stands near Olustee, Florida, led to the development of a culling scheme to eliminate poor-yielding trees. By culling 20 percent of the trees the average yield per face could be increased by 9 percent. Thus, more gum could be produced with no increase in labor per face.--SE (87).

Three widely separated PL-480 projects in Chile, Spain, and Israel have made significant contributions toward a basic understanding of the development and distribution of resin within a pine tree. In Chile the basic enzyme pathways by which terpenes are synthesized have been carefully studied in Pinus radiata and it is concluded that the biosynthesis of terpenes has several steps in common with the biosynthesis of isoprenoids in other plants. In Spain using P. pinaster it was learned that terpene composition changes with growth, but seedlings from high terpene parents produce more terpenes than seedlings from average parents. In Israel an anatomical study traced the origin, structure, development, and arrangement of the entire resin duct system within P. halepensis. All of these studies supplement the research into naval stores production that is being carried out by the Forest Service in Olustee, Florida.--WO (85, 86, 88).

(For additional items relating to III A see paragraphs under II G.)

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B. Breeding Improved Trees

1. DISTRIBUTION AND CLASSIFICATION OF FOREST TREES

A summary of the nomenclature and 22 distribution maps of subdivisions of the genus Pinus have been prepared from individual species maps of the 94 pine species of the world. These maps show clearly and graphically the maximum natural range of all component species. Thus, since artificial hybridization is likely to be more successful between closely related species, these maps may suggest localities as sources of germ plasm for hybridization for regions with similar climates.--WO (3).

As a Forest Service contribution to the International Biological Program, a study was made of the vegetation of Jost Van Dyke, one of the British Virgin Islands, located 5 miles north of St. Johns (U.S. Virgin Islands). It has 69 tree species recorded as native and 18 others as introduced.--WO (1).

2. INHERENT VARIATION

Substantial phenotypic variation in a species may indicate that important benefits can be obtained through a breeding program in that species. In sycamore occuring in natural stands in the lower Mississippi Valley, a high degree of phenotypic variation was found in 12 important growth, form, and wood quality characteristics. For almost all characteristics there was greater phenotypic variation within stands than between stands. Thus, emphasis should be placed on individual-tree selection rather than on selection of stands in tree improvement programs.--SO (20).

Individual tree and stand differences in specific gravity and fiber length were found in native stands of cherrybark oak in Tennessee and Mississippi. Specific gravity ranged from 0.53 to 0.69 and tracheid length ranged from 1.1 to 2.0 mm. The major component of variation was related to individual trees rather than stands or areas. These characteristics should be taken into account in the initial selection of individuals to be used in a breeding program with this species.--SO (8) .

Failure to select the best source of seed for a given site can result in substantial growth loss or even complete failure of a planting. The Southwide Pine Seed Source Study was established in 1951 to determine the distance that seed of southern pines could be moved. Well-defined variation patterns are evident in the 10- and 15-year-old plantations of the four species under test. In slash pine the most important variation was the poor survival and growth of trees from southern Florida in all plantings north of their point of origin. Seedlings from northwestern Florida did not survive planting as well as those from nearer the northeastern and western extremities of the range. Longleaf, shortleaf, and loblolly pines show growth variation that appears associated with seed source climate. Even when moved slightly north, trees from the warmer and wetter parts of the species range grew faster than those from the colder, drier parts. When moved to near the northern extremity of the species range, trees of southern origin grew more slowly than trees of a more northerly source. In loblolly pine the pattern of variation in resistance to fusiform rust was quite evident. Trees from west of the Mississippi River, southeastern Louisiana, and the eastern shore of Maryland are relatively resistant, while trees from other seed sources east of the Mississippi are more heavily infected. Maps showing seed collecting and planting zones have been prepared to take advantage of these results in tree improvement programs.--SO (22).

Local seed should be used in establishing loblolly pine plantations in Maryland and shortleaf pine stands in southern New Jersey or southeastern Pennsylvania. Local sources provide trees adapted to the local

climates and these trees usually grow faster in the Northeast than trees originating from seed collected further south. In Maryland, the local loblolly pine seed sources produced in 15 years 2.5 more cords of pulpwood per acre than the next best source. In New Jersey the local source of shortleaf pine produced about twice the basal area per acre and was 4 feet taller than the next best source after 10 years.--NE (17).

Differences in growth rate are usually evident when shortleaf pine seedlings from several geographic origins are planted on a given site. Understanding the causes of the differences would enable more efficient planning of tree selection in breeding programs. Physiological differences were found in roots of shortleaf pine from different geographic sources, but a study of plants where roots and tops were interchanged showed that the primary causes of seed source differences in growth occur in the above-ground portion of the trees.--SO (4, 5).

Sand pine has often been suggested for planting in the Georgia-Carolina Sandhills because of its ability to survive and grow well on deep, sterile sands. Third-year performance from plantations near Cheraw, South Carolina, and Columbus, Georgia, shows that the Ocala sand pine is damaged by freezing weather and should not be used. Choctawatchee sand pine is less susceptible to cold injury and grows faster than slash or loblolly on the Georgia site, a coarse Kershaw sand, but not on the somewhat better South Carolina site, a Troup sand.--SE (12).

Tests in southern Arkansas and northern Louisiana of 140 nonnative species, mainly pine and eucalyptus, showed that none grows as fast as the native loblolly pine after 9-12 years in the field.--SO (11).

Hybrids among the four major southern pines have been made repeatedly in all combinations except between longleaf and shortleaf. A 1959 trial of longleaf X shortleaf in Louisiana yielded 17 seedlings from 20 sound seed. Of these, five survive at Gulfport, Mississippi, and two have flowered. Anatomical and morphological characteristics generally fall intermediate between the two parent species and support the conclusion that the trees are F_1 interspecific hybrids of longleaf (female) and shortleaf (male) pines.--SO (7).

Wood volume production can be increased not only through superior growth rate but also through better survival of the seedlings. In a north Florida study of 14 fast-growing slash pine families, a severe drought period followed field planting. All of the fast-growing families included in this test grew faster than a check lot of commercial seedlings. Four of the families surpassed the commercial seedlings in survival. It thus appears feasible to select slash pine for both growth and drought resistance.--SE (21).

To understand the effects of cultural treatments and climate on the growth of black walnut, we must understand the seasonal growth patterns as well as how these patterns are affected by seed source and seed size. A recent study of black walnut seedlings showed that almost all height

growth occured in the first 6 weeks following germination while most of the stem, leaf, and root dry matter accumulated after the first 6 weeks. Although seedlings from southerly seed sources made the most height growth their limited winter hardiness restricts their use far north of the seed source location.--NC (6).

Trees from seven white spruce and six Norway spruce seed sources have grown in Wisconsin and Minnesota for 29 years. Measurements indicated the importance of seed source selection. Trees from some Norway spruce seed sources equaled or surpassed the native white spruce.--NC (16).

White spruce has a high productive potential, but successful plantation management in the northern Lake States is hindered by injury from late spring frosts. A study begun in 1958 has demonstrated that frost avoidance can be materially increased through breeding white spruce strains that begin growth late in the spring. Simultaneous breeding for rapid growth and frost avoidance is possible and would lead to substantial gains in overall growth.--NC (18).

Self-pollination in white spruce usually results in reduced seed set and a serious reduction in seedling vigor. The effect of self-pollination could be of particular importance in clonal seed orchards where the opportunity for selfing is relatively high. A Wisconsin study indicated that for the clones tested large differences in self-fertility occur between individual white spruce. Thus, selfing in white spruce clonal seed orchards may be minimized by eliminating the highly self-fertile individuals.--NC (15).

Heritability estimates are needed to predict progress in planning breeding programs. A study of heritability of height growth in western white pine nursery seedlings showed variations in 1- and 2-year heights due to additive gene effects. Those accounted for 33.9 and 35.9 percent respectively when based upon the combined male and female variances. The genetic improvement of growth rate in western white pine must be based on the selection of many parents chosen from a diversity of habitats.--INT (13).

Verification of seed origin continues to be a serious concern in nursery and planting programs. In a noble-Shasta red-California red fir species complex, preliminary information indicates that cotyledon number and seed weight increase systematically with latitude of origin from north to south. Direct measurement of these characteristics will help determine whether lots of unknown origin come from an appropriate latitude, thus eliminating a major source of plantation failure.--PNW (9).

In attempting to locate more productive tree varieties for use in Puerto Rican forest plantations, a comparative study of Mexican and Central American seed sources of mahogany (Swietenia macrophylla, S. humilis and S. mahogoni) was started. Preliminary results show that on subtropical, moist and wet sites, S. macrophylla is superior. On dry and

very dry sites the three species are about equal. Seed source differences were found within S. macrophylla and S. humilis.--ITF (10).

3. INSECT-DISEASE RESISTANCE

White pine blister rust is a serious disease on white pines the world over. Production of trees with genetic resistance to this disease promises to reduce the impact of this rust. Some sugar pine parent trees selected for rust resistance produced offspring with a simply inherited form of resistance, probably a single dominant gene. This finding offers the prospect of the successful reforestation of sugar pine sites in areas of high blister rust hazard.--PSW (26).

Morphological and biochemical data show that western seed sources of loblolly pine are more closely related genetically to shortleaf pine that are the eastern loblolly seed sources. Since shortleaf pine is considered immune to fusiform rust, the western sources of loblolly are concluded to owe their fusiform rust resistance to their relationship with shortleaf pine. Studies of plant proteins of loblolly, shortleaf, and their hybrids may lead to a better understanding of fusiform rust resistance and toward eventual control.--SO (24).

The European pine sawfly has caused widespread damage on several native and introduced pine species since its introduction into North America. Under a Forest Service grant to Yale University, the behavior of the insect on 500 pines (provenances and species hybrids) was observed over a 3-year period in northeast U.S. The insects apparently favored particular genotypes. This suggests that breeding insect resistant tree varieties is a feasible method of reducing damage from this insect.--WO (25).

4. TREE BREEDING METHODOLOGY

Artificial inoculation methods have been devised to identify pines having heritable resistance to fusiform rust. These procedures identified resistant selection in about one-fourth of the time required for field testing. Strong relationships were found between resistance to inoculation and field performance of progenies. Partially resistant individuals can be identified by artificial tests if both open- and controlled-pollinated progenies are used.--SO (31).

Selection for improved trees may be accomplished by selecting parents on the basis of their phenotype, or by progency testing, or by a combination of both. Studies of longleaf pine indicate that phenotypic selection of longleaf pine parents is effective in producing genetically superior progeny. Selecting the best 25 percent of the parents on the basis of parental phenotype produced progeny 12 percent taller than average. Selection based on the best 25 percent of the families from the progeny test resulted in an additional 23 percent gain. This extra gain indicates that the use of more expensive progency test methods is warranted in addition to parental phenotypic selection.--SO (41).

Genetically superior cottonwood can substantially increase the productivity of the thousands of acres of commercial plantations being established annually. To increase the speed with which select stock is incorporated into commercial plantings, more efficient testing methods have been developed. Preliminary results point to the use of extensive clonal selection in which large numbers of clones are tested to maintain a high selection differential. After one or two growing seasons, up to 10 percent of the clones are selected for long-term tests on a variety of sites. To develop improved varieties for the better cottonwood sites, selection and testing should be done only on these sites.--SO (37, 39).

Tree improvement programs involve recurring costs at various stages. Theoretical equations have been developed that can guide the tree breeder in allocating selection intensities in a seedling seed orchard program so that the breeder can achieve the maximum genetic gain per unit cost. Given reasonable cost estimates and reliable information on heritabilities, the tree breeder and seed orchard manager can use this method to allocate selection intensities to improve program efficiency.--SO (38).

The growth of hardwood seedlings in the nursery is strongly influenced by seedbed density. Progeny tests of sweetgum and sycamore have shown that variations in seedbed density due to differential sowing rates, germination, or survival can mask genetic variation in growth rate in the nursery and for several years after outplanting. Extreme care must be taken to insure a uniform seedbed density throughout the nursery period if early results of hardwood progeny tests are to be reliable.--SE (42).

Performance tests of slash pine selections based on clonal preparation will produce misleading results unless the age of the tree from which cuttings are taken is considered. Cuttings taken from older slash pine trees grow slower than cuttings taken from young trees. An adjustment, therefore, should be made for the age of the parent tree to avoid bias. There was an indication of physiological rejuvenation when cuttings were taken from 9- and 11-year-old rooted cuttings.--SE (33).

Sugar maple male flowers are relatively small and produce very small amounts of pollen which is sticky and hard to shake out. A hand-held vibrator was designed and tested on male sugar maple flowers at anthesis. Operation of this vibrator now makes possible collecting sugar maple pollen with less effort and greater efficiency.--NE (36).

Selections of superior sugar maples could be made at the nursery level if positive information was available on the juvenile and mature performances of trees. Measurements revealed significant differences among provenances in a number of juvenile characteristics during the nursery phase including height growth, forking, and survival. These provenances will be studied to check the relationship of their juvenile performances with subsequent stages in their development toward maturity.--NE (35).

Good quality Douglas-fir Christmas trees have always been at a premimum. Finding a source of seed that would consistently produce trees of good quality with a minimum of cultural treatment would greatly reduce the

cost of growing Christmas trees. Sixth year results of a Pacific Northwest study show that the quality of the Christmas trees has little relation to the appearance of the parent tree. The best way to evaluate a potential Christmas tree parent is to grow seedlings from that parent.--PNW (40).

Thousands of grafts are made each year to establish and maintain Douglas-fir seed orchards. Anatomical studies revealed that in most respects grafts of Douglas-fir followed developmental patterns previously reported for spruce and pine grafts, but specific differences were noted in contributing cell types, time of formation, and mode of healing. A study of survival after 6 months in the field revealed that the type of graft (cleft, splice, and side graft) was not a significant source of survival variation when 80 mm. or more of cambial contact connected the stock and scion. Graft incompatibility losses can be reduced in new clonal orchards by testing stock-scion combinations before introducing selected parents into the orchard. No relationship has been found between graft compatibility and the specific gravity of parent trees.--PNW (27, 28, 29, 30).

A method of permanently mounting wood fibers in polyvinyl acetate (Elmers Glue-all) has been developed that will considerably reduce the time and cost required in studies of fiber characteristics.--PSW (32).

(For additional items relating to III B see paragraphs under III A 1; to III B 3, see under II B8.)

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C. Low-Cost Housing

Detailed building plans for 11 low-cost wood homes of varying size and style are now available through the Government Printing Office. Plans complete with specifications and bill of materials are 18" x 24" in size, drawn to scale, and feature efficient use of wood at minimum cost. Also available is a 32-page brochure summarizing the 11 designs and briefly outlining salient features.--FPL (1, 2).

The most comprehensive and authoritative manual on general house-building, Agr. Handbook No. 73, Wood-Frame House Contruction, has been revised to include most recent information on homebuilding materials and practices. This 225-page manual can be used as a guide for builders, a training aid for apprentices, and as a guide to construction quality.--FPL (3).

Results of tests made during erection show contributions of specific components to the rigidity of a 36-foot clear-span building. Trusses, headers, walls, and roof sheathing made major contributions, and even shingles added some rigidity. Stiffness values were obtained for 24 different types of nailed or glued trussed rafters. Performances of finishes and fire-retardant treatments on wood panels and shingles is under continued observation.--FPL (7).

Sound insulation values of various apartment wall constructions are available from acoustical laboratories, but applicability to actual construction was not proven. Field measurements of sound transmission in 11 apartment buildings confirmed that wood-frame party walls can achieve the potential sound insulation shown by laboratory tests, provided design and workmanship are good and sufficient attention is given to detail.--PNW (8, 9).

Water repellent preservatives and heavily pigmented, penetrating-oil base stains provided an effective finish for rough-sawn southern pine surfaces. At least 3-year life with easy maintenance is expected. Details for an improved siding board also are briefly described.--SO (13).

The interaction of many different fire-retardant chemicals, resin binders, species of wood, and treating methods on the fabrication and final properties of particleboard were evaluated for flamespread, smoke production, strength, and stability. Certain borate and phosphate salt treatments applied to green particles showed superior performance.--FPL (15).

Damage following hurricane Camille was surveyed to observe structures evidencing resistance to wind and wave action. Wood-frame buildings exhibited remarkable resistance to wind forces that totally destroyed nearby structures. Wind damage to some wood-frame houses was obviously due to poor nailing. Pole-type foundations would have provided further protection from flooding and wave action.--SE (18).

Copper chromate in water solution, precipitated in surface fibers, produces a gray-green exterior natural finish that resists mildew and degradation by weathering. Results indicate a 4-year expected life for a one-coat application on siding, roofs, and fences.--FPL (4).

Building codes are frequently blamed for restricting construction of badly needed, low-cost rural housing. A survey in Georgia revealed that only one in seven counties and one in five rural cities use building codes. Thus, in Georgia at least, construction of low-cost rural housing is restricted by factors other than codes.--SE (19).

(For additional items relating to III C see paragraphs under II H 2.)

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D. Marketing Under-Used Species and Residues

Portable debarker-chippers may be suitable for disposing of thinnings, defective trees, and logging residues. Trial runs under various field conditions produced pulpable chips and provided data on factors affecting chip yield.--INT (4).

Increased coal production in the late 1960's brought an upturn in the market for wood products used in underground mines of the Appalachian bituminous coal region. In 1967, nearly 300 million board feet of sawn timbers and 159 million lineal feet of round and split timbers were used. Most of these products can be made from low-quality hardwoods and underused species. Growth of this market also created employment and increased income in rural areas of the region.--NE (5).

Where markets for sawed timbers are available, hardwood mill operators can increase their income from combined production of lumber and timbers. Sawing timbers from the poorest grade sound logs of least valuable species increased hourly income $5 to $10.--NE (2).

Estimated 1966 production of bark residues in the U.S. totalled 14 million tons, dry weight. These residues can be converted to useful products that will add to mill income and reduce environmental pollution caused by burning or dumping. This study of production and use of bark products in the U.S. provides data on costs and returns, and guides for firms interested in production of bark products.--NE (6, 7).

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E. Improving Income Opportunities

Interarea log shipments are limited in the Douglas-fir region; most logs are used in the area where harvested. Thus, competition for sales comes primarily from firms located in the same general area. Ten of the region's 15 functional economic areas are highly dependent on employment in timber-based industries.--PNW (1).

Most camp and picnic structures on public recreation areas of six North Central States are made of wood. This study of the number, type, and design of structures used; maintenance requirements and durability; methods of procurement; identity and location of purchasers will help existing or new wood product manufacturers provide better products to meet the increasing needs of this market.--NC (2, 3).

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F. Supply, Demand, and Price Analyses

Domestic production of timber products in 1969 is estimated at 11.2 billion cu. ft.--1 percent above 1968. Softwood stumpage prices declined sharply from alltime highs in the first quarter; eastern hardwood stumpage also dropped after the second quarter. Total lumber production was up slightly, reflecting a 14 percent increase in hardwood production and a 2 percent drop in softwoods. Plywood production was down slightly--about 1 percent for softwoods and 5 percent for hardwoods. Softwood lumber and plywood prices fell rapidly in early 1969 but have not changed much since midyear. Pulpwood production increased 7 percent nationwide, with a slight decline in the West. Prices continued a slowly rising trend.--WO (8).

Wood used in manufacturing was 11 percent greater in 1965 than in 1960. This study shows the amount of lumber, bolts, veneer, plywood, and other board products used, by type of industry and by product. Of the total wood used, 82 percent was lumber and 7 percent was plywood--down 2 percent from 1960. Consumption of particleboard increased sharply over 1960.--WO (6).

Almost 272 million cubic feet of wood products were treated with preservatives in 1968--5 percent less than in 1967. Poles, crossties, lumber, and timbers accounted for four-fifths of the volume treated. The remaining 20 percent was mostly fence posts and piling. Treatment of lumber, timbers, and plywood increased.--WO (7).

About 38.5 million fence posts were used annually between 1963 and 1966 on farms in Central and Appalachian States. Wood posts outnumbered metal by 2 to 1 in the Central Region and by more than 7 to 1 in the Appalachian Region. Total fence post use in the Central States seems to be declining due, in part, to increased use of treated wood posts which have a long service life.--NC (3).

A survey of homebuilders in the Washington Metropolitan area in late 1969 provided several indications of changes that could affect timber requirements for house construction. Builders are investigating and learning more about use of nonwood framing components; suppliers have plans to develop and merchandise nonwood materials; and builders' beliefs about comparative costs, craftsman resistance, and problems associated with using nonwood are being altered by experience and promotion by manufacturers of nonwood materials.--WO (11).

Forests of upper Michigan contain about 1.5 billion board feet of veneer logs of which three-fourths is hard maple and yellow birch. About 14 percent of hardwood sawtimber is suitable for veneer, ranging from 2.5 percent for paper birch to 20.6 percent for basswood.--NC (5).

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